UPPER MISSISSIPPI RIVER RESTORATION

ENVIRONMENTAL MANAGEMENT PROGRAM

POST-CONSTRUCTION

PERFORMANCE EVALUATION REPORT

2013

FOR

BIG TIMBER REFUGE

HABITAT REHABILITATION AND ENHANCEMENT PROJECT

US Army Corps of Engineers ®
Rock Island District

POOL 17

RIVER MILES 443.5 – 445.0

LOUISA COUNTY, IOWA

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

General. The design of the Big Timber Refuge Habitat Rehabilitation and Enhancement Project (HREP) was to provide the physical conditions necessary to improve and enhance aquatic, terrestrial and wetland habitat quality. As stated in the 1989 Definite Project Report, the Big Timber Refuge HREP was undertaken to address the following primary problem: loss of aquatic and wetland habitat due to sedimentation. HREP construction was initiated in 1989 and was substantially complete in 1991.

Purpose. The purposes of this Performance Evaluation Report (PER) are as follows:

1. Document the pre and post-construction monitoring activities for the Big Timber Refuge HREP.
2. Summarize and evaluate project performance on the basis of project goals and objectives as stated in the Definite Project Report (DPR).
3. Summarize project operation and maintenance efforts, to date.
4. Provide recommendations concerning future project performance evaluation.
5. Share lessons learned and provide recommendations concerning the planning and design of future HREP projects.

Project Goals and Objectives. The specific goals and objectives as stated in the DPR were to:

1. Enhance Aquatic Habitat
    a. Restore deep aquatic habitat ($\geq$ 6 ‘)
    b. Restore shallow aquatic habitat (2’ $\leq$ 3’)
    c. Improve levels of dissolved oxygen during critical seasonal stress periods
    d. Provide year round habitat access
2. Enhance Terrestrial Habitat
    a. Produce mast tree dominated areas
3. Enhance Migratory Waterfowl Habitat
    a. Increase reliable resting and feeding water areas
    b. Provide isolated resting, feeding, and breeding pools

Project Performance Monitoring. Pre and post-project monitoring, both qualitative and quantitative, was performed in accordance with Section 12, Project Performance Assessment, from the original DPR. Monitoring and performance evaluation was conducted by the U.S. Army Corps of Engineers, the Iowa Department of Natural Resources, and U.S. Fish and Wildlife Service. The period of data collection covered in this report includes the pre-project monitoring (1998), quantitative and qualitative post-project monitoring through 2013, and anecdotal information through 2013.

Evaluation of Project Objectives. For the evaluation period of 2007 to 2013, observations were made with regard to the efficacy of the objectives in meeting project goals. In addition, general conclusions were drawn regarding project measures that may affect future project design.

1. ENHANCE AQUATIC HABITAT
    a. Restore deep aquatic habitat (Depth $\geq$ 6')
        i. Evaluation Criteria: Hydrographic soundings indicate 42.4 acre-feet of habitat, 6 feet of depth or greater at flat pool, in Willow Chute, Timber Chute and Round Pond by Year 50.
        ii. Pre-Project Condition: Zero acre-feet of deep aquatic habitat.
        iii. General Observation: Sedimentation has occurred in the dredged channels, eliminating the project deep aquatic habitat.
        iv. Results: There appear to be no areas of deep aquatic habitat in Willow Chute, Timber Chute and Round Pond based on hydrographic transects. Average depth in Round Pond is 2.9 feet, average depth in Timber Chute is 1.75 feet, average depth in Willow Chute is 2.4 feet.
        v. Success: The project appears to be unsuccessful in maintaining deep aquatic habitat and overwintering habitat for fish.
        vi. Conclusion: Sedimentation rates appear to have been greater than estimated in the DPR, as the deeper part of dredged areas have been filled, with some areas filled by 2004.
        vii. Lessons Learned & Recommendations: The criteria utilized in evaluating the HREP performance for this objective was sufficient.

    b. Restore shallow aquatic habitat (2'$\leq$Depth$\leq$3')
        i. Evaluation Criteria: Hydrographic soundings indicate 15.8 acre-feet of habitat between 2 and 3 of depth at flat pool in the HREP by Year 50.
        ii. Pre-Project Condition: Zero acre-feet of shallow aquatic habitat.
        iii. General Observation: Sedimentation has occurred in the dredged channels, resulting in a reduction of shallow aquatic habitat.
        iv. Results: Shallow aquatic habitat volume in Round Pond is 2.3 acre-feet, Timber Chute 1.1 acre-feet, Big Denny is 0 acre-feet, in Little Denny it is 0 acre-feet, and in Willow Chute is 6.7 acre-feet.
        v. Success: The project was minimally successful in maintaining shallow aquatic habitat between 2 and 3 feet below flat pool.
        vi. Conclusion: Sedimentation rates appear to have been greater than estimated in the DPR, as many parts of dredged areas have been filled in, with some areas filled by 2004.
        vii. Lessons Learned & Recommendations: The criteria utilized in evaluating the HREP performance for this objective was sufficient.

    c. Improve levels of dissolved oxygen during critical seasonal stress periods
        i. Evaluation Criteria: Maintain dissolved oxygen (DO) concentration $\geq$ 5 mg/L by Year 50.
        ii. Pre-Project Condition: DO concentrations < 5 mg/L.
        iii. General Observation: Project has often been ineffective at providing sufficient DO concentrations.

iv. Results: Average daytime DO concentrations from 2006 to 2010 are near 8 mg/L, with periods during winter and summer where DO fell below 5 mg/L. Typical periods of low DO last only a couple of hours, but some events lasted a couple days or more.
v. Success: The goal of DO concentrations > 5 mg/L has not been met.
vi. Conclusion: The project has been mostly successful at maintaining the required DO concentrations; however, time periods below 5 mg/L are occurring. These periods of low concentrations occur primarily during the summer months, when oxygen production via photosynthesis is insufficient in compensating for oxygen consumption by way of respiration. Prolonged periods of high water have also had a negative impact on oxygen concentrations.
vii. Lessons Learned & Recommendations: Diurnal fluctuations of DO concentrations in backwaters of the UMR during the summer months are typical. It is not uncommon for night time DO concentrations to fall below 5 mg/L. These short episodes below 5 mg/L do not appear to significantly impact fish because fish kills are rarely reported in the HREP. If a numerical DO concentration is used for future HREPs, it is recommended that diurnal DO fluctuations are taken into account when determining the project criterion.

d. Provide year round habitat access
    i. Evaluation Criteria: Maintain a channel cross section area of 348 square feet or greater.
    ii. Pre-Project Condition: Zero square feet of channel cross section area.
    iii. General Observation: The average channel cross section area deeper than 3.5 feet below flat pool (532.5 ft ASL) has decreased due to sedimentation.
    iv. Results: 14 hydrographic transects were conducted. Nine transects had zero square feet of cross-section area below elevation 532.5. The average cross-section area of the remaining transects was 67 square feet.
    v. Success: The objective of 348 square feet of channel cross section area has not been met.
    vi. Conclusion: The project has been unsuccessful in maintaining year round habitat access.
    vii. Lessons Learned & Recommendations: The criteria utilized in evaluating the HREP performance for this objective was sufficient.

2. ENHANCE TERRESTRIAL HABITAT
    a. Produce mast tree dominated areas
        i. Evaluation Criteria: Maintain mast tree dominated areas > 240 acres by Year 50
        ii. Pre-Project Condition: 170 acres of mast trees.
        iii. General Observation: Mast trees planted during construction and during a supplemental planting in 2004 appear to be successful with the exception of impacts from beavers.
        iv. Results: Mast trees planted were identified, analyzed, and recorded for species, status, and size. It doesn't appear trees have suffered mortality from natural stressors (e.g., water inundation and duration). However, a significant number of planted trees have suffered mortality from beaver felling and limited growth due to herbivory and natural stressors.
        v. Success: Trees planted on the dredged material placement site have been successful, but the acreage of mast tree dominated plots is <240 acres. Recruitment is near zero in and around the planted area, which limits the growth in acreage of mast tree dominated plots.
        vi. Conclusion, Lessons Learned, and Recommendations: Water inundation and duration has a profound effect on the growth, reproduction, and recruitment of mast trees in the Mississippi River floodplain. Trees planted on the elevated dredged material placement site have generally survived, but growth is limited and recruitment is essentially non-existent. Lack of recruitment is most likely a result of water inundation and lack of sufficient open area on the berm for tree growth.

3. ENHANCE MIGRATORY WATERFOWL HABITAT
    a. Increase reliable resting and feeding areas
        i. Evaluation Criteria: Maintain areas $\geq$ 21 acres by Year 50
        ii. Pre-Project Condition: Zero acres of habitat.
        iii. General Observation: Although channel realignment/sedimentation has occurred, significant areas of resting and feeding are present.
        iv. Results: The 2013 sedimentation survey indicated a total of 54.3 acres of resting and feeding water areas in the channels and potholes. Channel surface water area has increased, while pothole surface water has continued to decline.
        v. Success: The evaluation criteria has been met.
        vi. Conclusion: The project appears successful in meeting the objective.
        vii. Lessons Learned & Recommendations: The evaluation criteria is adequate for evaluating project performance.

b. Provide isolated resting, feeding and brooding pools
    i. Evaluation Criteria: Maintain 10 potholes by Year 50
    ii. Pre-Project Condition: Zero potholes.
    iii. General Observation: Ten potholes are still in existence, but with decreased overall dimension.
    iv. Results: The average long chord length of the potholes is 60.4 feet. The average short chord length of the potholes is 33.7 feet. The average depth is 1.8 feet. These dimensions have decreased from 2002 averages of 77 feet for long chord, 38 feet for short chord, and 2.1 feet for depth.
    v. Success: The objective of maintaining 10 potholes is being met.
    vi. Conclusion: The project is mostly successful at maintaining the potholes, although sedimentation is decreasing the surface area and depth.
    vii. Lessons Learned & Recommendations: The evaluation criteria is adequate for evaluating project performance.

Overall, the HREP has been degraded since construction, specifically since the early 2000's. Sedimentation is the primary reason, impacting the dredged areas and potholes, and access. The HREP was unable to maintain the desired DO concentrations during critical stress periods. However, waterfowl feeding/resting areas are still adequate, and a significant amount of the mast tree plantings are still present.

Evaluation of Project Operation and Maintenance. The O&M manual was completed in June 1994. Periodic maintenance is required on the dredged material placement sites, dredged channels, check dams and potholes and planting sites. O&M costs through 2012 were approximately $9,000. Regular site inspections by the HREP Manager have resulted in proper coordination and corrective maintenance actions.

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POOL 17
MISSISSIPPI RIVER MILES 443.5 – 445.0
LOUISA COUNTY, IOWA

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BIG TIMBER REFUGE

HABITAT REHABILITATION AND ENHANCEMENT PROJECT

POOL 17

MISSISSIPPI RIVER MILES 443.5-445.0

LOUISA COUNTY, IOWA

1. INTRODUCTION

The Upper Mississippi River Restoration Environmental Management Program (UMRR-EMP) is a Federal-State partnership to manage, restore and monitor the UMR ecosystem. The UMRR-EMP was authorized by Congress in Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662) and reauthorized in 1999. Subsequent amendments have helped shape the two major components of EMP – the Habitat Rehabilitation and Enhancement Projects (HREPs) and Long Term Resource Monitoring (LTRM). Together, HREPs and LTRM are designed to improve the environmental health of the UMR and increase our understanding of its natural resources.

Habitat Rehabilitation and Enhancement Project (HREP) construction is one element of the UMRR-EMP. In general, the projects provide site-specific ecosystem restoration, and are intended and designed to counteract the adverse ecological effects of impoundment and river regulation through a variety of modifications, including flow introductions, modification of channel training structures, dredging, island construction, and water level management. Interagency, multi-disciplinary teams work together to plan and design these projects.

The Big Timber Refuge HREP (Big Timber HREP) is part of the UMRR-EMP. This project consisted of a confined dredged material placement site, channel excavation, check dam construction, pothole creation and mast tree plantings that were designed to enhance wetland, aquatic and terrestrial habitat. A Site Plan displaying the aforementioned features is included on Sheet C-101 in Appendix B.

1.1 Purpose of Project Evaluation Reports

The purposes of this Project Evaluation Report for the Big Timber HREP are to:

A. Document the pre and post-construction monitoring activities for the Big Timber HREP.
B. Summarize and evaluate project performance on the basis of project goals and objectives as stated in the Definite Project Report (DPR).
C. Summarize project operation and maintenance efforts, to date.
D. Provide recommendations concerning future project performance evaluation.
E. Share lessons learned and provide recommendations concerning the planning and design of future HREP projects.

1.2 Scope

This report summarizes available monitoring data, operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) information, and observations made by the U.S. Army Corps of Engineers (USACE), and U.S. Fish and Wildlife Service (USFWS). The period of data collection covered in this report includes post construction monitoring from 2007 to 2013.

1.3 Project References

Published reports which relate to the Big Timber HREP are presented below.

A. Big Timber Refuge, Upper Mississippi River System Environmental Management Program, Definite Project Report (R-5) with Integrated Environmental Assessment, Pool 17, Louisa County, Iowa, USACE Rock Island, IL; July 1989.
B. Big Timber Refuge, UMRR-EMP, Post Construction Performance Evaluation Report (PER5D), Pool 17, Louisa County, Iowa, USACE Rock Island, IL; October 1995.
C. Big Timber Refuge Rehabilitation and Enhancement, Operation and Maintenance Manual, Upper Mississippi River, Louisa County, Iowa, USACE Rock Island, IL: June 1994. Construction contracts DACW25-90-C-0040 and DACW25-93-C-0034.
D. Big Timber Refuge Rehabilitation and Enhancement, UMRR-EMP, Post Construction Performance Evaluation Report (SPER501F), Pool 17, Louisa County, Iowa, USACE Rock Island, IL; August 1998.
E. Big Timber Refuge Rehabilitation and Enhancement, UMRR-EMP, Post Construction Performance Evaluation Report (PER5F), Pool 17, Louisa County, Iowa, USACE Rock Island, IL; February 1996.
F. Big Timber Refuge Rehabilitation and Enhancement, UMRR-EMP, Post Construction Performance Evaluation Report –Year 9 (2000), Pool 17, Mississippi River Miles 443.5-445.0, Louisa County, Iowa, USACE Rock Island, IL; June 2001.
G. Big Timber Refuge Rehabilitation and Enhancement, UMRR-EMP, Post Construction Performance Evaluation Report –Year 10 (2001), Pool 17, Louisa County, Iowa, USACE Rock Island, IL; March 2002.

H. Big Timber Refuge Rehabilitation and Enhancement, UMRR-EMP, Post Construction Performance Evaluation Report –Year 15 (2006), Pool 17, Louisa County, Iowa, USACE Rock Island, IL; June 2007.

1.4 Project Location

The Big Timber HREP is located in Louisa County, Iowa, on the right descending bank of the Mississippi River, between river miles 443.5 and 445.0 (Figure 1 – Big Timber Refuge HREP Project Area). The project is operated by the USFWS as a management unit of the Port Louisa National Wildlife Refuge.

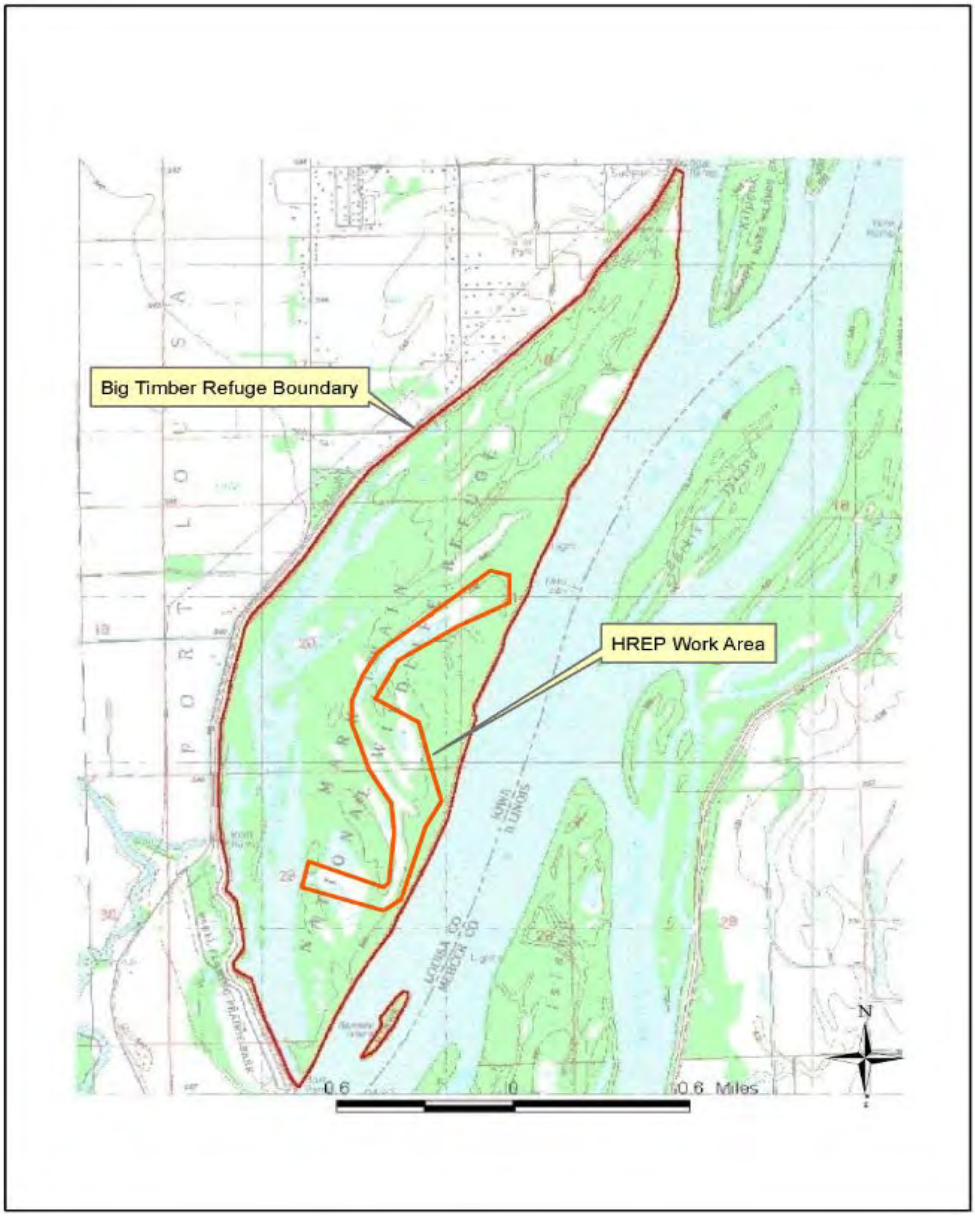


Figure 1. Big Timber Refuge HREP Project Area

2. PROJECT PURPOSE

2.1 Overview

The design of the Big Timber HREP was to provide the physical conditions necessary to improve habitat quality. The specific goals as stated in the Definite Project Report (DPR) were to: enhance aquatic habitat, enhance terrestrial habitat, and enhance migratory waterfowl habitat. In order to achieve these goals, the decrease in dissolved oxygen levels and areas of rapid sediment accumulation needed to be addressed. The problems, opportunities, goal, objectives and measures implemented to address the goals and objectives are listed in Table 1.

Table 1. Problems, goals, objectives, and measures

PROBLEMS	GOALS	OBJECTIVES	RESTORATION MEASURES
Rapid accumulation of sediment reduced habitat quality and quantity. Dissolved oxygen values falling to critical levels.	Enhance Aquatic Habitat	Restore deep aquatic habitat (Depth > 6’)	Hydraulic dredging
		Restore shallow aquatic habitat (2’< Depth< 3’)	Mechanical excavation
		Improve levels of DO during critical seasonal stress periods	Dredging and excavation
		Provide year round habitat access	Dredging and excavation
	Enhance Terrestrial Habitat	Produce mast tree dominated areas	Revegetation
	Enhance Migratory Waterfowl Habitat	Increase reliable resting and feeding water areas	Pothole creation, dredging and excavation
		Provide isolated resting, feeding and brooding pools	Pothole creation

3. PROJECT DESCRIPTION

3.1 Project Measures

The Big Timber HREP included a combination of hydraulic dredging, mechanical excavation, pothole creation and mast tree planting (see Figure 2 for locations of measures). A detailed description of each of these measures is provided below.

A. Creation of Deep Channels. Hydraulic dredging of approximately 74,000 cubic yards to create a 50 foot wide channel from the mouth of Round Pond to the mouth of Timber Chute (1,120 feet long), and the head end of Timber Chute to the mouth of Big Denny (3,950 feet long). Minimum dredging depth was to elevation 528 (8 feet below Pool 17 flat pool of elev. 536). Hydraulically dredged material was placed in a confined dredged material placement site (CPS) between the Mississippi River and Big and Little Denny. In addition, approximately 5,500 cubic yards were mechanically excavated from Timber Chute to provide a 35 foot wide by 327 foot long channel through Timber Chute. Timber Chute minimum excavated depth was to elevation 528 (8 feet below Pool 17 flat pool). Mechanically excavated material was sidecast on both banks of Timber Chute.

B. Shallow Habitat Excavation. Mechanical excavation of approximately 63,500 cubic yards from the mouth of the Willow Chute area to the heads of Big and Little Denny to provide a 40 to 50 foot wide by 9,400 foot long shallower area (located immediately adjacent to the hydraulically dredged channel in Willow Chute). Minimum excavated depth was to elevation 532.5 (3.5 feet below Pool 17 flat pool).

C. Check Dams. Construction of three check dams from mechanically excavated material at those locations where overland flows are depositing sediment at the project site. In areas where mud flats were encroaching on existing ponds or channels, the material from mechanical excavation was placed along the bank of the mud flat. Check dams were constructed at four locations to an approximate elevation of 543 feet MSL.

D. Potholes. Explosives were used to blast 10 holes in the mud flats where willows were encroaching. These holes have since filled with water and now provide secluded open water areas for wood duck broods to rest, feed, and breed. The potholes were constructed to have a surface area of approximately 40 feet by 70 feet with a depth of 8 feet.

E. Boater Access Control. Creation of boater access control was done by the placement of cleared timber at several locations in the dredged channel.

F. Mast Tree Planting. Revegetation was done by planting 900 trees consisting of 11 mast-producing species on the CPS containment dike.

The deep dredging was designed to restore over-winter and summer thermal refuge areas for fish. The shallower areas will increase fish spawning and nursery habitat. Planting mast trees will enhance terrestrial habitat value. The increase in acreage of year-round open water will increase habitat available to wood duck broods, and the creation of potholes in the mudflat area will provide protected areas for wood ducks.

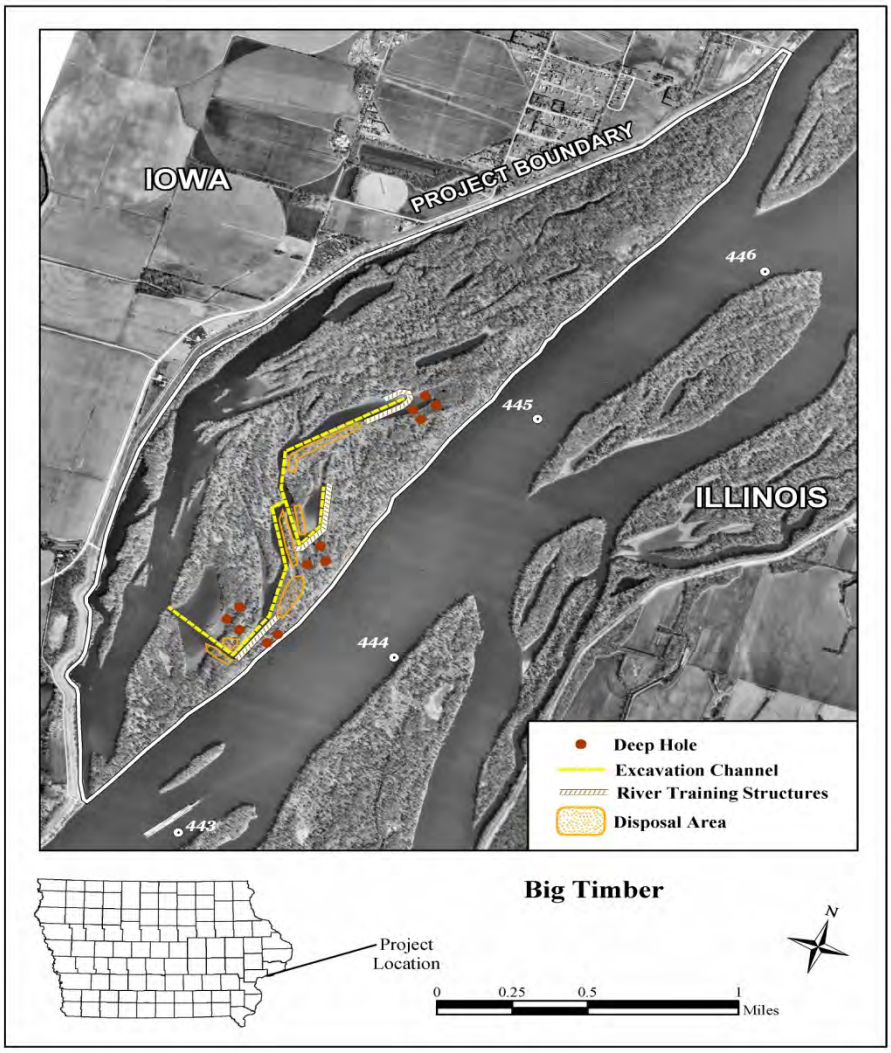


Figure 2. Big Timber HREP Project Measures

3.2 Project Construction

The Big Timber HREP project was approved for construction in June 1990 at an estimated cost of $851,000 (equivalent to $1,266,396 in FY2012). The Stage 1 Contract was awarded in May 1990, consisted of dredging and pothole creation activities and was completed in September 1991. Stage II was awarded in June 1993, consisted of revegetation activities, and was completed in the fall of 1995. The disturbed area seeding part of the contract was deleted after it was determined that vegetative cover reestablished shortly after construction. Pothole construction was modified due to impracticality of standardizing pothole dimensions.

In 2004, the Rock Island District conducted a supplemental forestry planting within the HREP project boundaries. Due to mortality of planted trees on the berm, 49 trees consisting of 34 swamp white oak and 15 bur oak species, were planted to replace those which experienced mortality.

3.3 Project Operation and Maintenance

General. In the original DPR it was estimated that the Big Timber HREP would require little or no maintenance. Operation and maintenance responsibilities for the Big Timber HREP were originally outlined in the DPR. The acceptance of these responsibilities was formally recognized by an agreement signed by the USFWS and the Rock Island District, USACE.

A detailed description of all operation and maintenance requirements can be found in the Project Operation and Maintenance Manual (O&M Manual). The O&M Manual for the project delegated responsibilities and procedures for post project activities. Project operation and maintenance generally consists of the following:

A. Project inspections conducted annually each May.
B. Project inspection during and after periods of high water.
C. Advance measures ensuring availability of labor and materials.
D. Conduct actions to correct adverse conditions including but not limited to debris removal, waste material removal, herbicide treatment and removal of unauthorized structures.

Project Measures Requiring Operation and Maintenance. Maintenance of the project measures was to be completed on an as-needed basis to maintain their structural integrity and continued function in the manner for which they were designed.

4. PROJECT PERFORMANCE MONITORING

4.1 General

Performance monitoring on the Big Timber HREP has been conducted by USACE to help determine the extent to which the design meets the habitat improvement objectives. Information from this monitoring will also be used, if required, for adaptive management.

The monitoring and performance evaluation matrix is outlined in Table 2. Pre and post-project monitoring, both qualitative and quantitative, by each of the involved agencies is summarized below.

A. U.S. Army Corps of Engineers: The success of the project relative to original project objectives shall be measured utilizing data, field observations, and project inspections provided by USFWS and USACE. The Corps of Engineers was responsible for post-project analyses of water quality, sedimentation, and vegetation. The Corps of Engineers has overall responsibility to measure and document project performance.
B. U.S. Fish and Wildlife Service: The USFWS is responsible for operating and maintaining the Big Timber HREP. USFWS was responsible for post-project annual inspections.
C. Iowa Department of Natural Resources: The Iowa Department of Natural Resources (DNR) has collected fish data in the past, which is not currently identified as a monitoring requirement. The DNR is to be present at joint inspections.

Table 2. Monitoring and Performance Evaluation Matrix

Activity	Purpose	Responsible Agency	Implementing Agency	Funding Source	Remarks
Sedimentation Problem Analysis	System-wide problem definition. Evaluates planning assumptions	USFWS	USFWS (EMTC)	LTRMP	Leads into pre-project monitoring; defines desired conditions for plan formulation
Pre-project monitoring	Identifies and defines problems at HREP site. Established need for proposed project feature	Sponsor	Sponsor	Sponsor	Attempts to begin defining baseline. See DPR.
Baseline monitoring	Establishes baselines for performance evaluation	USACE	Field station or sponsor thru Cooperative Agreements or Corps	LTRMP	See DPR for location and sites for data collection and baseline information. Actual data collection will be accomplished during Plans & Specification phase.
Data Collection for Design	Includes identification of project objectives, design of project, and development of performance evaluation plan	USACE	USACE	HREP	Comes after fact sheet. This data aids in defining the baseline
Construction Monitoring	Assesses construction impacts; assess permit conditions are met	USACE	USACE	HREP	Environmental protection specifications to be included in construction contract documents. Inter-agency field inspections will be accomplished during project construction phase
Performance Evaluation Monitoring	Determine success of project as related to objectives	USACE (quantitative), sponsor (field observations)	Field station or sponsor thru Cooperative Agreements or Corps	LTRMP Cooperative	Comes after construction phase of project
Analysis of Biological Responses to Project	Evaluates predictions and assumptions of habitat unit analysis. Determine critical impact levels, cause-effect relationships, and effect on long-term losses of significant habitat	USFWS	USFWS (EMTC)	LTRMP	Problem Analysis and Trend Analysis studies of habitat projects

4.2 Project-Induced Habitat Changes

Construction of the Big Timber HREP increased the size and volume of potential overwintering and shallow water fish habitat compared to pre-project conditions. This habitat included areas with deep water, low flows, increased temperatures, and adequate dissolved oxygen such that several fish species could survive throughout the winter season. Shallow water habitat was also constructed to provide increased acreage of spawning and rearing habitat. Although aquatic vegetation doesn't appear to be successful in the shallow water areas, the habitat afforded by the project is adequate for spring through fall reproduction and rearing.

The construction of an elevated dredged material placement site provided suitable conditions for mast tree establishment which did not exist previously. The berm not only provides an elevated planting site, but it also appears the berm has served as a sediment deflector. This was apparent through the increased elevation of ground upstream of the berm as compared to immediately upstream. Although this is purely anecdotal, it appears the berm was providing at least some protection to the backwaters from sedimentation.

The subsequent planting of mast trees also provided habitat which didn't previously exist. Mast trees are important food sources for a variety of wildlife which utilize floodplain habitat. This food source is somewhat limiting within the island complex as there are only small patches of mast producing trees. Although recruitment is not yet evident in and around the mast tree plantings, the planted trees are producing mast and providing a valuable food source. Increased floodplain elevation in and around the planted trees would certainly increase the likelihood for successful recruitment.

Finally, the floodplain potholes created during project construction represent habitat which did not previously exist within the island complex. The potholes offer secluded, vegetated, and water filled depressions throughout the project area for waterfowl, reptiles & amphibians, and other wildlife feeding, foraging, and reproduction. The potholes have succumbed to sedimentation from water inundation during flooding, but still offer a unique habitat within the complex.

4.3 Non-Project-Induced Habitat Changes

As with many projects located within the river, flooding plays a major role in habitat change. In the Big Timber project area sedimentation continues to be a significant driver of habitat quality. Backwaters located within and outside of the project area have experienced diminished ecological returns each year due to sedimentation.

Old growth forest stands within the island complex have experienced mortality through old age, animal induced mortality, and water inundation mortality. This has led to decreased forest habitat, but also creates habitats through snags and voids in the overstory. Snags are used by

multiple species of floodplain wildlife, but most importantly it is critical habitat for the federally endangered Indiana bat which uses the habitat as roosting and rearing habitat. Voids in the overstory create opportunities for forest succession and understory growth.

5. PROJECT EVALUATION

5.1 Construction and Engineering

Construction began in May 1990 and was initially completed in the summer of 1992, except for the planting of mast trees. Mast trees were planted in 1993 with final construction completed in spring of 1995. In 2004, the Rock Island District conducted a supplemental forestry planting within the HREP project boundaries. Due to mortality of planted trees on the berm, 49 trees consisting of 34 swamp white oak and 15 bur oak species, were planted to replace those which experienced mortality.

The disturbed area seeding portion of the contract was deleted after it was determined that vegetative cover had re-established shortly after construction.

Pothole construction to standard dimensions was deemed impractical during construction activities. Final pothole dimensions ranged from 24 to 50 feet wide, 60 to 80 feet in length and 5 to 11 feet in depth.

5.2 Costs

In the original DPR, cost estimates for the entirety of the project were $1,028,000. Actual project costs (planning, engineering, design and construction) costs were $731,762. As of 2011, the total cost of the Big Timber HREP was $851,000.

5.3 Operation and Maintenance

In the original DPR, over the 50-year project life the estimated cost for operation and maintenance was $375,000. From the estimate, an average annual operation and maintenance cost was calculated to be $7,500. This amount included project inspections, debris removal, herbicide treatment and removal of unauthorized structures. To date, the total documented OMRR&R cost has been $9,000, with the estimated average annual cost to be $500.

5.4 Ecological Effectiveness

The HREP objectives and how they pertain to the ecological effectiveness of the project are discussed below. Monitoring target values were developed in the 1995 PER based on as-built conditions. Table 4 summarizes the performance evaluation plan and schedule for the Big Timber HREP goals and objectives.

A. Restore deep aquatic habitat (depth > 6')

General. One of the specific project objectives for the Big Timber HREP was to restore deep aquatic habitat. Hydraulic and mechanical dredging was conducted in 1991 to create 8-foot deep channels in Round Pound, Timber Chute and Willow Chute. The Year 50 target is 42.4 acre-feet of deep aquatic habitat.

Pre- and Post-Project Conditions. Prior to construction, the aquatic habitat in the HREP was being steadily degraded by sedimentation. Based on 1938 and 1988 data, the DPR estimated an average annual sedimentation rate of 0.51 inches per year throughout the Big Timber HREP. However, the DPR estimated an average annual sedimentation rate of 0.62 inches per year in channeled areas (Round Pond) since this area is more susceptible to sediment deposition. The DPR also stated that detailed historical records of sedimentation rates were practically nonexistent. In Year 11 (2002), the average deep aquatic habitat sedimentation rate was estimated at 1.9 inches per year, which is three times the DPR rate. The Mississippi River was identified as the dominant source of the sediments, consisting of fine silts and clays.

Sedimentation transects were conducted in Round Pond, Timber Chute and Willow Chute in 1991, 1994, 1997, 2004, and 2013. The flat pool elevation is 536.0 feet ASL. To ascertain the volume of deep aquatic habitat, the area of each transect below an elevation of 530.0 feet ASL (6 feet below flat pool) was determined. Round Pond, Timber Chute and Willow Chute are represented by transects A, B, C, D, E, F, G, H and I. Channel Transect Plates are provided in Appendix B. The transects indicate that deep aquatic habitat appears to have been destroyed due to sedimentation. There are currently no transects with a depth greater than or equal to 530.0 feet ASL. The transects were previously surveyed in 2004. Only transects E, F, G, H and I had deep aquatic habitat at that time. Table 3 displays the change in deep aquatic volume over time.

Table 3. Deep Aquatic Habitat Volume over time

Year	Volume of Deep Aquatic Habitat (acre-feet)	Average Depth (feet)
0 (1991)	67.2	6.5
3 (1994)	63.6	6.0
6 (1997)	57.8	5.1
11 (2002)	49.9	4.9
22 (2013)	0	1.9

At the time the project was built and for several additional years the project areas most likely provided adequate deep water and overwintering habitat. Fish and creel surveys conducted by the IA DNR during the growing season documented new fishing opportunities throughout the project site, but did not document increases in populations, size, or harvest (Schonhoff and Cornish 1996). Nonetheless, the increased depth provided by the project site likely increased use during the winter and survivability for a variety of fish species, which cannot easily be documented in Mississippi River backwater habitats.

Currently, the project site does not include sufficient acreage of deep water habitat. Small pockets of deep water may exist within areas not influenced by sedimentation, but these areas probably do not function as high quality overwintering areas as they are small in size, somewhat inaccessible, and sporadically located throughout the backwaters.

Although the site does not contain suitable overwintering habitat, the habitat is still functioning as quality habitat for spawning, foraging, and rearing during the growing season. Recent fish surveys in June 2012 indicate at least seven species of game fish utilize the area. Even with decreased depths, fishermen are able to access most of the project site for recreation.

Conclusion. The project measures provided the desired deep aquatic habitat volume through at least 2002. The project's current condition will be unsuccessful in providing the ability to maintain deep aquatic habitat. In 2002 the volume of deep aquatic habitat was calculated to be 49.9 acre-feet. The current volume is 0 acre-feet. The period from 2004 to 2013 indicated significant sedimentation, likely due in part to Mississippi River flooding in 2008, 2010, 2011 and 2012. Based on hydrographic transects, there is no deep aquatic habitat left in the dredged channels as designed. There are no other apparent areas of deep aquatic habitat in the HREP work area. At least one additional round of hydrographic transects is recommended in the next PER (FY2018), as to gain better understanding of the sedimentation processes at the HREP, and help determine alignments of any future work.

B. Restore shallow aquatic habitat (2'<depth<3')

General. Restoration of shallow aquatic habitat was another primary objective for the HREP. Mechanical excavation was conducted to create channels with a four foot depth in Willow Chute and Big and Little Denny ponds. The Year 50 target is 15.8 acre-feet of shallow aquatic habitat.

Pre- and Post-Project Conditions. Based on 1938 and 1988 data, the DPR estimated an average annual sedimentation rate of 0.51 inches per year throughout the Big Timber HREP. The DPR also stated that detailed historical records of sedimentation rates were practically nonexistent. In Year 11 (2002), the average shallow aquatic habitat sedimentation rate was

estimated at 2.5 inches per year, which is four times the DPR rate. The Mississippi River was identified as the dominant source of the sediments, consisting of fine silts and clays.

Sedimentation transects were conducted in Willow Chute, Big Denny and Little Denny in 1991, 1994, 1997, 2004 and 2013. The volume of shallow aquatic habitat was calculated by measuring the area of each transect between elevation 534.0 (2 feet below flat pool) and elevation 533.0 (3 feet below flat pool) was determined. Round Pond, Timber Chute, Willow Chute, Big Denny and Little Denny are represented by transects A, B, C, D, E, F, G, H, I, J, K, L, M and N. Channel Transect Plates are provided in Appendix B. The transects indicate that most shallow aquatic habitat appears to have been eliminated by sedimentation. Round Pond, Timber Chute and Willow Chute are the only areas of the HREP with remaining shallow aquatic habitat. Big Denny and Little Denny have 0 acre-feet, Round Pond has 2.3 acre-feet, Timber Chute has 1.1 acre-feet, and Willow Chute has 6.7 acre-feet of shallow aquatic habitat. The transects were previously surveyed in 2004. Transects A, B, C, D, E, F, G, H, I, J, K, L, M and N had shallow aquatic habitat at that time. Table 4 displays the change in shallow aquatic habitat volume over time.

Table 4. Shallow Aquatic Habitat Volume over time

Year	Volume of Shallow Aquatic Habitat (acre-feet)	Average HREP Depth (feet)
0 (1991)	61.2	6.5
3 (1994)	63.1	6.0
6 (1997)	59.3	5.1
11 (2002)	92.4	4.9
22 (2013)	10.1	1.9

Shallow water habitat within the Mississippi River corridor is generally not limiting. However, within the project site the objectives of the project was to target specific depths to facilitate increases in aquatic vegetation growth, increase spawning habitat availability, and provide transitional habitat between deep water and shallow water shelves. Since construction the depth within the shallow water site has been decreasing and is no longer within the target range. Very little aquatic vegetation has been noted within the project site since construction and surveys conducted as part of this PER only resulted in collections of duckweed. Generally, aquatic vegetation limiting within this reach of the river as compared to northern reaches. The driver responsible for the limited aquatic vegetation has not yet been determined, but stressors generally include high turbidity, fluctuating water levels, and herbivory. Transitional habitat no longer exists as sedimentation has filled-in deep water channels and shallow water habitat

resulting in little depth variability. The resulting conditions offer little for unique habitat within the Big Timber complex.

Conclusion. The project measures provided the desired shallow aquatic habitat volume through at least 2002. The project's current condition will be unsuccessful in providing the ability to maintain shallow aquatic habitat. In 2002 the volume of shallow aquatic habitat was calculated to be 92.4 acre-feet. The current volume is 10.1 acre-feet. The period from 2002 to 2013 indicated significant sedimentation, likely in part due to Mississippi River flooding in 2008, 2010, 2011 and 2012. Based on hydrographic transects, there is some shallow aquatic habitat left in the dredged channels as designed, approximately 43% of the Year 50 target of 15.8 acre-feet. At least one additional round of hydrographic transects is recommended in the next PER (FY2018), as to gain better understanding of the sedimentation processes at the HREP, and help determine alignments of any future work.

C. Improve levels of dissolved oxygen during critical seasonal stress periods

General. Increasing the dissolved oxygen (DO) levels at the HREP during winter and summer months is a project objective. Hydraulic dredging and mechanical excavation of sediments was conducted to eliminate shallow off channel areas.

Pre- and Post-Project Conditions. Sedimentation due to Mississippi River flood events reduced the amount of deeper off-channel aquatic habitat and connectivity between off-channel habitats. This aquatic habitat and connectivity reduction had led to fish kills during severe winter and summer conditions, attributable to low dissolved oxygen levels over an extended period of time, as well as to fish becoming stranded or concentrated in unconnected waters once flood waters recede. The severe winter and summer fish kills were typically observed during the summer when high water temperatures persisted and in the winter when snow covered the ice for a long duration of time.

During the study period, EC-HQ staff performed water quality monitoring at sites W-M443.6G and W-M444.4H. Data gathered by the staff included a combination of both periodic grab samples and in-situ continuous monitors (YSI model 6000, 6600, or 6600-V2 and Hach DS5X series sondes). Grab samples were collected just below the surface on 38 occasions. The two monitoring sites were visited approximately twice a month from June to September and three times total during the months of December through March (approximately every sixth week) each year. Sampling typically was not performed during the months of April, May, October, and November. Water quality parameters typically measured were: water depth, velocity, wave height, air and water temperature, cloud cover, wind speed and direction, DO, pH, total alkalinity, specific conductance, Secchi disk depth, turbidity, suspended solids, chlorophyll (a, b, and c), and pheophytin a. In-situ water quality monitoring sondes were deployed on most

sampling trips to both sites. Sondes were positioned three feet off the bottom, or two feet from the water surface during most deployments. Deployment duration was typically two weeks during summer months and around six weeks during the winter. The sondes normally monitored the water quality parameters of: DO, temperature, pH, specific conductance, depth, and turbidity. Data was recorded every two hours during deployments.

In comparing pre and post-construction average DO concentrations since the Big Timber Refuge project's dredging was completed in the fall of 1991, there appears to be no distinct trend in DO concentrations. When looking at grab sample results, there appears to be a slight decrease the first couple of years post project completion, followed by approximately 10 years of improved DO values during the previous reporting period. However during the current monitoring period of 31 May 2006 to 8 September 2010, grab sample results seem to indicate a slight decrease, especially throughout the high water and low DO event during the summer of 2010. Part of the reason for the average DO value decline during this monitoring period is the long flood season of 2010, which saw low DO values that could partially be attributable to high water levels, low algal driven photosynthesis, and high suspended sediment loads.

Even though average DO concentrations started to decrease during this monitoring period, generally there was little potential for negative impacts to aquatic biota since continuous monitoring data indicates that most of the low DO events where values dropped below 5.0 mg/L were of short duration, typically diurnal in nature. No fish kill information is available to help assess potential impacts to fish as a result of the low DO events that occurred during this monitoring period, especially during the critical winter and summer seasons identified in the Big Timber project's DPR.

In general, results from the current evaluation period indicate that the Big Timber Refuge project has not been effective at providing sufficient DO concentrations to meet the project objective identified in Section 4 of the Big Timber DPR of maintaining a dissolved oxygen concentration greater than or equal to 5 mg/L. On several occasions at both sites (during both the winter and summer seasons), the target level of 5.0 mg/L was not met, with some low DO events lasting for several consecutive days. The summer season had more occasions where DO dropped below the 5.0 mg/L target than the winter. This trend is most noticeable at site M444.4H where 35% of the summer grab sample results indicated low DO as opposed to 17% of the winter sampling results.

Conclusion. The project measures were somewhat successful in providing the ability to meet the DO concentrations criteria during critical stress periods. In general, results from the current evaluation period indicate that the Big Timber Refuge project has been mostly effective at providing sufficient DO concentrations to support aquatic life, yet there were numerous instances at both sites (both during the winter and the summer) when the target level of 5.0

mg/L was not met, sometimes for several consecutive days. Continued sedimentation and decreased water depths in backwater areas, though, have already begun to reduce the effectiveness of the project to produce the water quality objectives. Continued monitoring at the two water quality stations is recommended.

D. Provide year round habitat access

General. An objective related to deep and shallow habitat is providing year round habitat access through mechanical and hydraulic dredging. The Year 50 target is to maintain an average channel cross-section area of 348 square feet or greater at Willow Chute, and 258 square feet or greater at Timber Chute. It is of equal and related importance to maintain a flat pool depth of 3.5 feet or greater.

Pre and Post-Project Conditions. Sedimentation had reduced the suitable year round habitat prior to construction. Based on 1938 and 1988 data, the DPR estimated an average annual sedimentation rate of 0.51 inches per year throughout the Big Timber HREP. The Mississippi River was identified as the dominant source of the sediments (fine silts and clays).

Sedimentation transects were conducted in Round Pond, Timber Chute, Willow Chute, Big Denny and Little Denny in 1991, 1994, 1997, 2004 and 2013. Channel Transect Plates are provided in Appendix B. The area of year round habitat access was calculated by measuring the area of each transect below the elevation 532.5 feet ASL (3.5 feet below flat pool). The transects indicate that a significant decrease in year round habitat access has occurred. Only Round Pond (Transects A and B) and a section of Willow Chute (Transects G, H and I) have any access area that meets the aforementioned criteria. The average cross-section area of these transects is 67 square feet, the maximum area is 88 square feet at Transect A, with a minimum of 19 square feet at Transect B. All other transects indicated 0 square feet. The transects were previously surveyed in 2004. Transects A, B, C, D, E, F, G, H, I, and L had year round habitat access that met criteria at that time. Table 5 displays the change in shallow aquatic habitat cross sectional area over time.

Table 5. Year Round Habitat Access Cross-Section area over time

Year	Year Round Cross Sectional Area (square feet)
0 (1991)	567
3 (1994)	542
6 (1997)	476
11 (2002)	534
22 (2013)	67

Conclusion. The project measures provided the desired cross sectional access area through at least 2002. The project's current condition will be unsuccessful in maintaining year round habitat access. In 2002 the average year round habitat cross section area was calculated to be 534 square feet. The current average cross section area volume is 67 square feet. The period from 2004 to 2013 indicated significant sedimentation, likely in part due to Mississippi River flooding in 2008, 2010 and 2011. Based on hydrographic transects, there is some year round access left in Round Pond and Willow Chute, but there is an overall lack of interconnectedness between dredged areas. At least one additional round of hydrographic transects are recommended in the next PER (FY2018), as to gain better understanding of the sedimentation processes at the HREP, and help determine alignments of any future work.

E. Provide mast tree dominant areas

General. One of the specific project objectives for the Big Timber HREP was to restore greater than 204 acres of mast tree dominated forest by year 50. Records indicate approximately 620 trees were planted during initial construction and another supplemental planting was initiated in 2004 in support of mast tree production within the complex. These trees were planted on the dredged material placement berm for increased elevation and reduction of potential water inundation from high water.

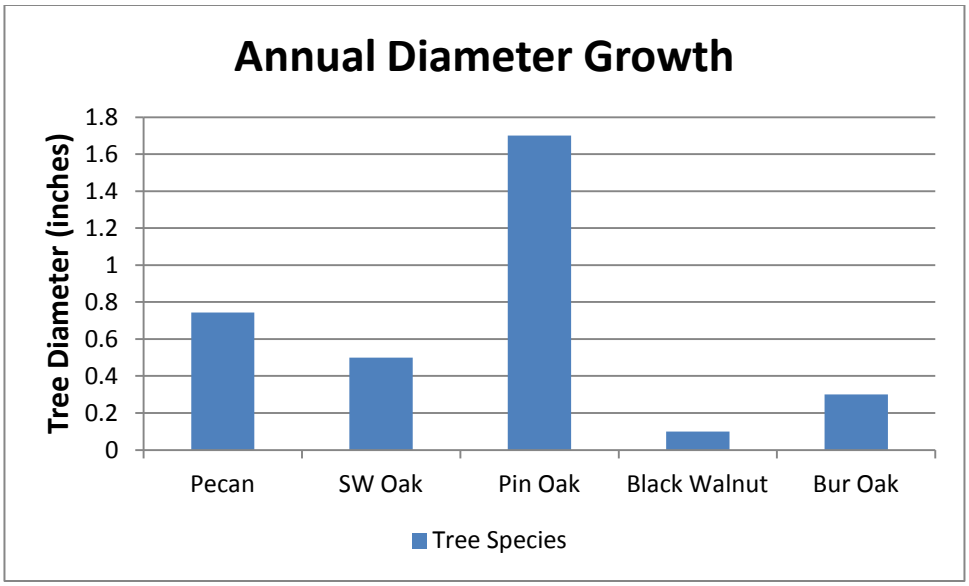
Pre and Post-Project Conditions. Following lock and dam construction on the UMR, water levels are generally higher over the entire year, flood pulses are higher, and periods of very low flow formerly common in the fall have been eliminated. Consequently, nearly the entire complex is located at or below an elevation suitable for optimal survival, growth, and sustainability of mast tree production (DeJager et al. 2012).

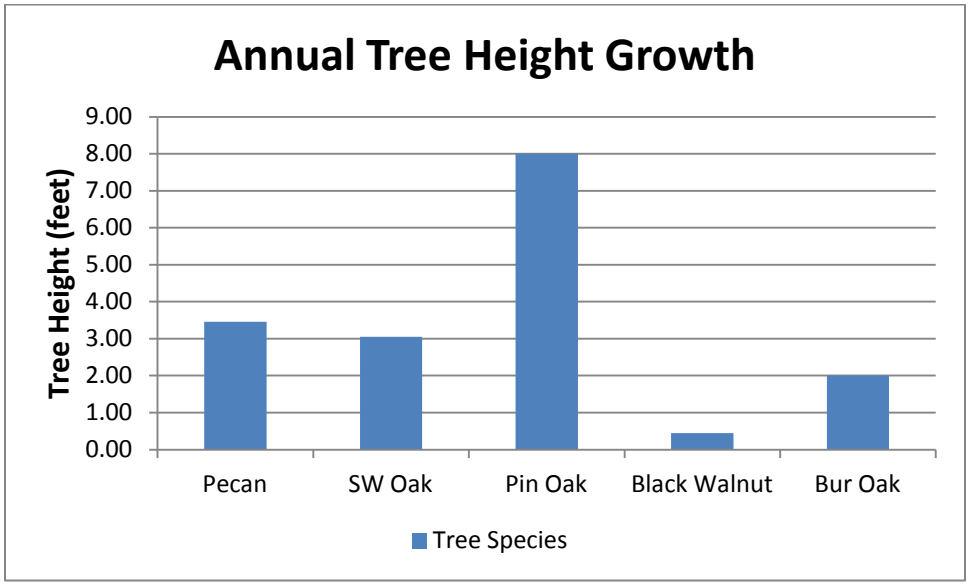
Before construction the Big Timber complex and project site was mostly dominated by water tolerant species such as silver maple or eastern cottonwood. Smaller components of moderately flood tolerant species such as American sycamore, green ash and common hackberry were also found within the overstory canopy layer. Oak and hickory hard mast tree species can still be observed and maintain a presence within the overstory canopy layer. Hard mast tree species can be found on approximately 240 acres within the Big Timber complex. No regeneration of any hard mast tree species was observed during the forest inventory data collection. Understory is generally dominated by American elm and red mulberry even in areas that are dominated by hard mast tree species. Additionally, the stands of water tolerant species present under pre-project conditions were even-aged mature trees on the brink of mortality from old age or flooding. This is concerning as tree loss creates openings in the canopy which encourages the growth of nondesirable herbaceous vegetation if advanced regeneration of tree seedlings isn't occurring. This dense growth prevents recruitment of desirable tree species through direct competition of tree saplings. On average, the forested

community within Big Timber was established around 1940. A few stands of hard mast trees date back to the early 1900's and all potentially could be lost without artificial manipulation through topographic diversity and tree planting efforts. Examples of this cycle can be found within many island complexes in the UMRS where natural mortality of mature trees has resulted in dense stands of the invasive reed canary grass and limited recruitment of desirable trees.

As mentioned, the project sought to restore additional acreage of an uneven aged hard mast tree dominated forest community. Approximately 640 mast producing trees and shrubs (e.g., pecan, pin oak, walnut, red osier dogwood, high bush cranberry; all likely bareroot plantings) were planted in 1993 with another supplemental planting in 2004 (i.e., bur oak, swamp white oak; RPM #3), along the dredged material placement site (~2-year flood elevation) as a means to increase their elevation compared to flat pool. This method reduces water inundation and duration impacts on the trees and increases survivability and potential recruitment.

It appears from routine site-visits that the tree plantings have been generally successful. With the exception of beaver impacts, most plantings have survived significant flooding and other natural stressors. Growth has been limited within the project site, but this is common with mast producing trees planted at lower elevations (<2 year flood). Species survivability, from highest to lowest survivability, amongst planted trees can be observed as pecan, swamp white oak, black walnut, and pin oak, respectively. Several of the trees planted during the initial construction planting are producing nuts which are providing food sources for a variety of wildlife species utilizing the complex. The swamp white oak and bur oak trees planted during the 2004 supplemental planting are generally small and not producing nuts, but are contributing to a higher diversity within the forest community. Several have experienced significant damage from beaver activity. Recruitment of mast producing trees planted during the initial construction is non-existent. The constructed berm which provides increased elevation is quite small and only allows for one row of trees. This and routine flooding has probably prevented mast producing tree recruitment in the project site. Having said this, recruitment of desirable soft mast trees species (i.e., Kentucky coffeetree, honey locust, river birch) were observed and this can be attributed to increased topographic diversity. These species didn't appear to be planted within the project site, but were recorded during the survey.





Conclusion. The project objective of greater than 240 acres of mast producing trees has not yet been met. However, the trees planted during construction and supplemental plantings have been fairly consistent in their growth and development, by species, based on other tree plantings located within the floodplain forest. Hard mast recruitment will continue to be limited given the hydrograph and beaver herbivory within this area. Planting of containerized tree species provides additional vertical height to alleviate some flooding concerns and also allows for them to compete with most herbaceous species. Measures to protect trees from beaver herbivory would increase species survival exponentially. Trees aren't as susceptible to mortality from flood events once they have reached 5 years in age since they are typically not completely inundated for long periods of time, generally. The area is experiencing

establishment of volunteer species like the Kentucky coffeetree, honey locust, and river birch which all attribute to species diversity.

As mentioned, the berm created from dredged material was not appropriately sized which is contributing to limited growth and recruitment. Ideally, the berm would be built to an elevation no less than the 2-year flood event. Additionally, the berm would be sufficiently sized to accommodate several rows of adequately spaced trees and additional room for recruitment of additional trees. The current berm represents about 10% and 40% of the ideal width and height, respectively.

F. Increase reliable resting and feeding water areas

General. Creation of aquatic habitat and pothole construction were utilized to increase the area of reliable resting and feeding water for migratory waterfowl. The Year 50 target level for this objective is 21 acres or greater of water surface area, including channels and potholes.

Pre and Post-Project Conditions. The DPR indicated the migratory waterfowl use of the Big Timber HREP area had been in decline, partially due to population declines, but also due to dwindling aquatic and wetland habitats with adequate food production and open water area. Sedimentation from overland flooding from the Mississippi River was determined to be the primary cause of the reduction of reliable surface water area.

Sedimentation transects were conducted in each of the ten potholes, Round Pond, Timber Chute, Willow Chute, Big Denny and Little Denny in 1991, 1994, 1997, 2004 and 2013.

The channel surface area was determined by multiplying the channel width at flat pool for each transect by the channel length between transects. The pothole water surface area was determined by multiplying the pothole long chord length by the pothole short cord length. The 2013 transects are included in Appendix B, Plate C-301 through C-312. The 2002 PER determined a total of 50.6 acres of suitable water surface area was present (50.0 acres channel surface area, 0.63 pothole surface area). The 2013 data indicates that 54.3 acres of surface water area is present, of which 53.9 acres are channel surface water area, and 0.4 acres are pothole surface water area. Table 6 displays the change in channel and pothole water surface area over time.

Table 6. Reliable Resting and Feeding Surface Water Area

Year	Channel Surface Water Area (acres)	Pothole Surface Water Area (acres)	Total Surface Water Area (acres)
0 (1991)	23.2	0.6	23.8
3 (1994)	25.8	0.77	26.6
6 (1997)	27.1	0.79	27.9
11 (2002)	50.0	0.63	50.6
22 (2013)	53.9	0.4	54.3

Conclusion. The project measures were successful in providing the ability to increase reliable resting and feeding surface water area. Since the most recent PER in 2002, moderate to significant sediment accumulation occurred at nearly all the transects. Despite this occurrence, the surface water area available for waterfowl increased by approximately four acres from 2002 to 2013. This indicates that while sediment is shifting due to normal currents or flood events, overall channel area is not changing significantly. Pothole surface area, increased in the first six years after construction, but after a series of major flood events since 2001 has continued to decline. The next sedimentation survey will occur in FY2018.

G. Provide isolated resting, feeding and brooding areas

General. Creation of ten potholes was conducted to enhance migratory waterfowl habitat. These potholes were designed as isolated resting, feeding and brooding pools. The Year 50 target level is maintaining of a total number of ten potholes.

Pre and Post-Project Conditions. Prior to project construction, sedimentation had converted aquatic areas to wetlands, and wetlands to terrestrial habitats. A lack of isolated pools, open water and access to available food was determined to be contributing to a decline in migratory waterfowl at Big Timber. As part of the HREP, ten potholes were constructed with dimensions varying from 24 to 50 feet in width and from 60 to 80 feet in length.

Sedimentation transects were conducted in each of the ten potholes 1991, 1994, 1997, 2004 and 2013. The 2013 pothole transects are included in Appendix B, Plate C-309 through C-312. The long chord and short chord length for each pothole was measured, and averages were calculated. The 2013 data indicates that the average pothole long chord length is 60.4 feet, while the average short chord length is 33.7 feet. The average pothole depth at flat pool is 1.8 feet. Table 7 displays the change in pothole dimensions over time.

Table 7. Isolated Resting, Feeding, and Brooding Area Dimensions

Year	Pothole Long Chord Average Length (feet)	Pothole Short Chord Average Length (feet)	Pothole Average Depth (feet)
0 (1991)	0	0	0
4 (1995)	151	68	3.5
6 (1997)	154	70	3.4
11 (2002)	77	38	2.1
22 (2013)	60.4	33.7	1.8

Fluctuations in potholes dimensions are likely flood related, as there were no major floods between 1995 and 1997 (period of erosion), two major floods between 1997 and 2002 (period of siltation), and three major floods between 2002 and 2013 (period of siltation). Although the potholes are experiencing sedimentation, they still provide unique habitat opportunities for a variety of migratory waterfowl, reptiles, amphibians, and wildlife. Aquatic vegetation does not appear to be common within the potholes, but other moist soil species are present in and around the potholes. Also, they continue to exhibit qualities necessary for brood rearing, foraging, and loafing such as large woody debris, vegetation, and water.

Conclusion. The potholes have experienced significant sedimentation, do not contain aquatic vegetation, and are small in surface acres. Due to their size, the potholes are limited in their carrying capacity for waterfowl. However, they still contribute to habitat diversity for select waterfowl and amphibians for feeding, loafing, and brood rearing. In this respect, the potholes continue to provide unique and diverse habitat.

Additional design for the construction of the potholes may have helped to reduce the level of sedimentation and increase the habitat quality afforded by the project features. Pothole location (e.g., distance from main channel; parallel vs. perpendicular to flow), dimensions (e.g., large vs. small; linear vs. circular), structure (e.g., large woody debris; vegetation), and O&M play an equally large role in the ability to provide sustained high quality habitat for waterfowl.

Table 8. Performance Evaluation and Monitoring Schedule

Goal	Objective	Enhancement Measure	Units	Monitoring Target Values			Monitoring Schedule
				Year 0 without project	Year 22 with project	Year 50 target with project	
Restore Aquatic Habitat	Restore deep (>6') aquatic habitat	Hydraulic dredging	Acre-feet	0	0	42.4	Hydrographic soundings of transects
	Restore shallow aquatic habitat	Mechanical Dredging	Acre-feet	0	10.1	15.8	Hydrographic soundings of transects
	Improve DO levels	Dredging/Excavation	mg/L	<5	Avg 7-8	5.0	Water quality monitoring at STN W-M443.6G
	Provide year round habitat access – cross sectional area	Dredging/Excavation	Square feet	0	67	348 (Willow) 258 (Timber)	Hydrographic soundings of transects
Enhance Terrestrial Habitat	Produce mast tree dominated areas	Mast tree plantings on dredged material placement site	Acres of mast trees	170[a]	240[b]	240	Vegetation surveys of transects
Enhance Migratory Waterfowl Habitat	Increase reliable resting and feeding areas	Pothole creation, dredging, excavation	Acres	0	54.3	21	Hydrographic soundings of transects
	Provide isolated resting, feeding and breeding pools	Pothole creation	# of potholes	0	10	10	Aerial surveys

[a] Estimate represents total acreage of mast producing trees in the project area and adjacent floodplain.

[b] Of the total only 26 acres of mast producing trees are a result of the project features.

6. LESSONS LEARNED AND RECOMMENDATIONS FOR FUTURE SIMILAR PROJECTS

A. The berm created from dredged material was not appropriately sized which is contributing to limited growth and recruitment. Ideally, the berm would be built to an elevation no less than the 2-year flood event. Future HREPs incorporating mast tree plantings on berms of increased elevation should be sufficiently sized to accommodate more than one row of trees, space for adequate spacing, and additional room for recruitment. The berm at Big Timber represents about 10% and 40% of the ideal width and height, respectively.

B. Location (e.g., distance from main channel; parallel vs. perpendicular to flow), dimensions (e.g., large vs. small; linear vs. circular), structure (e.g., large woody debris; vegetation) should be considered during design and construction when restoring potholes habitat. Accounting for these physical characteristics and design criteria may have helped to reduce the level of sedimentation and increase the habitat quality afforded by the project features.

C. Anecdotal evidence suggests the constructed berm slows water down before entering the backwater which causes sediment to drop out before going over the berm during flood events. It appears this has resulted in increased elevation of floodplain upstream of the berm. This process doesn't appear to be limiting sedimentation within the dredged backwater or channels, but an increase in floodplain elevation could eventually provide additional acreage for mast producing trees. Similar projects in the future should consider this as a potential method to increase floodplain elevation throughout the project life.

D. Although the narrow constructed berm was insufficiently sized to provide significant acreage for mast producing trees, it does appear it successfully reduces sedimentation on top of the berm. This is important as sedimentation on newly planted trees has been shown to be detrimental to the development and growth of mast producing trees.

E. Diurnal fluctuations of DO concentrations in backwaters of the UMR during the summer months are typical. It is not uncommon for night time DO concentrations to fall to below 5.0 mg/L. These short episodes below 5.0 mg/L do not appear to significantly impact fish because fish kills are rarely reported here. If a numerical DO concentration criteria is used for future HREPS, it is recommended that diurnal DO fluctuations are taken into account when determining the project criterion.

7. CONCLUSIONS

Overall, the HREP has been degraded since construction, specifically since the early 2000's. Sedimentation is the primary reason, most likely due to significant flooding in 2008, 2010, 2011 and 2012. The dredged deep aquatic habitat has been eliminated, the dredged shallow aquatic habitat has been greatly reduced, access cross –sectional area has been significantly reduced, and the pothole surface area has been reduced. The HREP was unable to maintain the desired DO concentrations during critical stress periods. However, waterfowl feeding/resting areas are still adequate, and a significant amount of the mast tree plantings are still present.

8. REFERENCES

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Appendix A

Big Timber Refuge PER (Water Quality)

BIG TIMBER REFUGE POST-CONSTRUCTION PERFORMANCE EVALUATION REPORT WATER QUALITY ANALYSIS

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BIG TIMBER REFUGE PERFORMANCE EVALUATION REPORT (WATER QUALITY)

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2. Objectives: Improve dissolved oxygen levels during critical seasonal stress periods

3. Enhancement Features: Selective dredging

4. Background: Per Table 4-1 of the Big Timber Refuge Rehabilitation and Enhancement DPR dated July of 1989, the water quality related objective is to improve levels of dissolved oxygen during critical seasonal stress periods. Associated with this objective, the Big Timber Refuge project aims to increase fish habitat in the backwater area off Coolegar Slough and to increase overwintering fish habitat. Sedimentation due to Mississippi River flood events reduced the amount of deeper off-channel aquatic habitat and connectivity between off-channel habitats. This aquatic habitat and connectivity reduction has led to fish kills during severe winter and summer conditions, attributable to low dissolved oxygen levels over an extended period of time, as well as to fish becoming stranded or concentrated in unconnected waters once flood waters recede. The severe winter and summer fish kills were typically observed during the summer when high water temperatures persisted and in the winter when snow covered the ice for a long duration of time. Snow cover on ice prevents sunlight from transmitting through the ice into the water, thus reducing or eliminating photosynthesis. The longer ice and snow cover is on the water surface, then the longer that respiration is occurring at a greater rate than photosynthesis, leading to reduced dissolved oxygen.

As identified in Section 4 of the Big Timber DPR, a goal of the project is to maintain dissolved oxygen (DO) concentrations greater than or equal to 5 mg/L. To measure the success of this goal, baseline monitoring commenced on May 6th 1989 at water quality monitoring site W-M443.6G. Once project construction was completed, post-project monitoring began on September 24th, 1991 at this site. Another monitoring site, W-M444.4H, was added to the post-project monitoring effort on November 7th, 1995. See Plate 1 for water quality monitoring sampling site locations.

Since post-project monitoring began, there have been multiple performance evaluation reports completed for Big Timber Refuge, with the latest completed in 2006. This report evaluates water quality data collected by USACE Water Quality and Sedimentation Section (EC-HQ) personnel from May 2006 to September of 2010. Due to the cyclical nature of Rock Island District's EMP water quality monitoring program, sampling was not continuous for each site during the whole observation period.

During the study period noted above, EC-HQ staff performed water quality monitoring at sites W-M443.6G and W-M444.4H. Data gathered by the staff included a combination of both periodic grab samples and in-situ continuous monitors (YSI model 6000, 6600, or 6600-V2 and Hach DS5X series sondes). Grab samples were collected just below the surface on 38 occasions. The 2 monitoring sites were visited approximately twice a month from June to September and three times total during the months of December through March (approximately every sixth week) each year. Sampling typically was not performed during the months of April, May, October, and November. Water quality parameters typically measured were: water depth, velocity, wave height, air and water temperature, cloud cover, wind speed and direction, DO, pH, total alkalinity, specific conductance, Secchi disk depth, turbidity, suspended solids, chlorophyll (a, b, and c), and pheophytin a. In-situ water quality monitoring sondes were deployed

on most sampling trips to both sites. Sondes were positioned three feet off the bottom, or two feet from the water surface during most deployments. Deployment duration was typically two weeks during summer months and around six weeks during the winter. The sondes normally monitored the water quality parameters of: DO, temperature, pH, specific conductance, depth, and turbidity. Data was recorded every two hours during deployments.

5. Monitoring Results: Complete grab sample water quality results from post-project monitoring are found in Appendix B of this report. For pre-project baseline monitoring, refer to Appendix B Water Quality of the Definite Project Report (DPR) with Integrated Environmental Assessment for Big Timber Refuge Rehabilitation and Enhancement.

The following tables provide a summary of grab sample DO concentration results at each monitoring site during both pre- and post-project construction.

Site W-M443.6G:

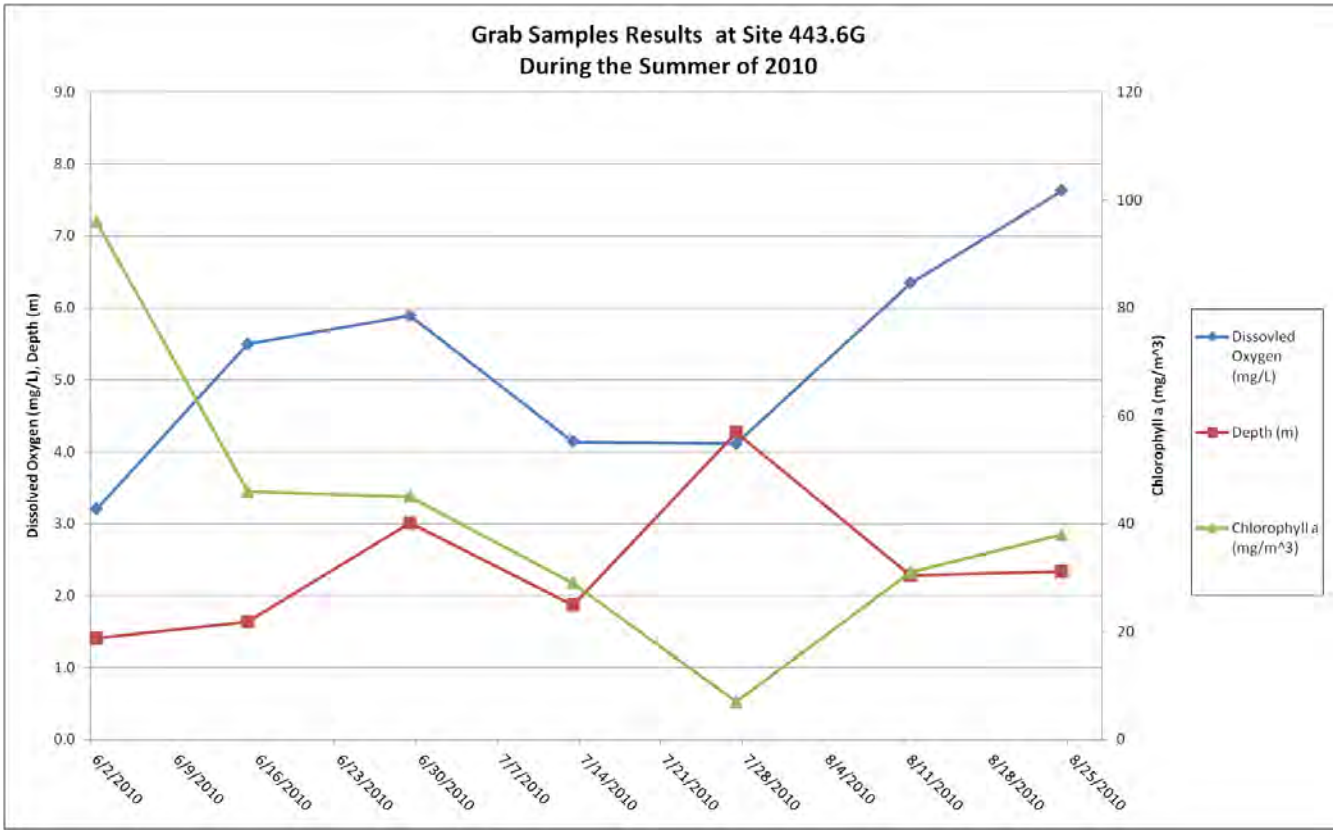
	Pre-Project Construction	Post-Project Previously Evaluated	Post-Project Monitoring Update
	05/06/89 - 09/29/90	09/24/91 - 03/16/06	05/31/06 - 09/08/10
Total Times DO Sampled:	24	155	37
Total Samples with DO Concentrations Below 5.0 mg/L:	2 (8%)	25 (16%)	5 (14%)
Number of Winter Samples:	0	45	6
DO Concentrations Below 5.0 mg/L during Winter Sampling:		5 (11%)	1 (17%)
Number of Summer Samples:	24	110	31
DO Concentrations Below 5.0 mg/L during Summer Sampling:	2 (8%)	20 (18%)	4 (13%)
Minimum DO Concentration (mg/L)	0.6	1.7	2.7
Maximum DO Concentration (mg/L)	19.7	21.3	18.5
Average DO Concentration (mg/L)	10.5	9.0	8.4

Site W-M444.4H:

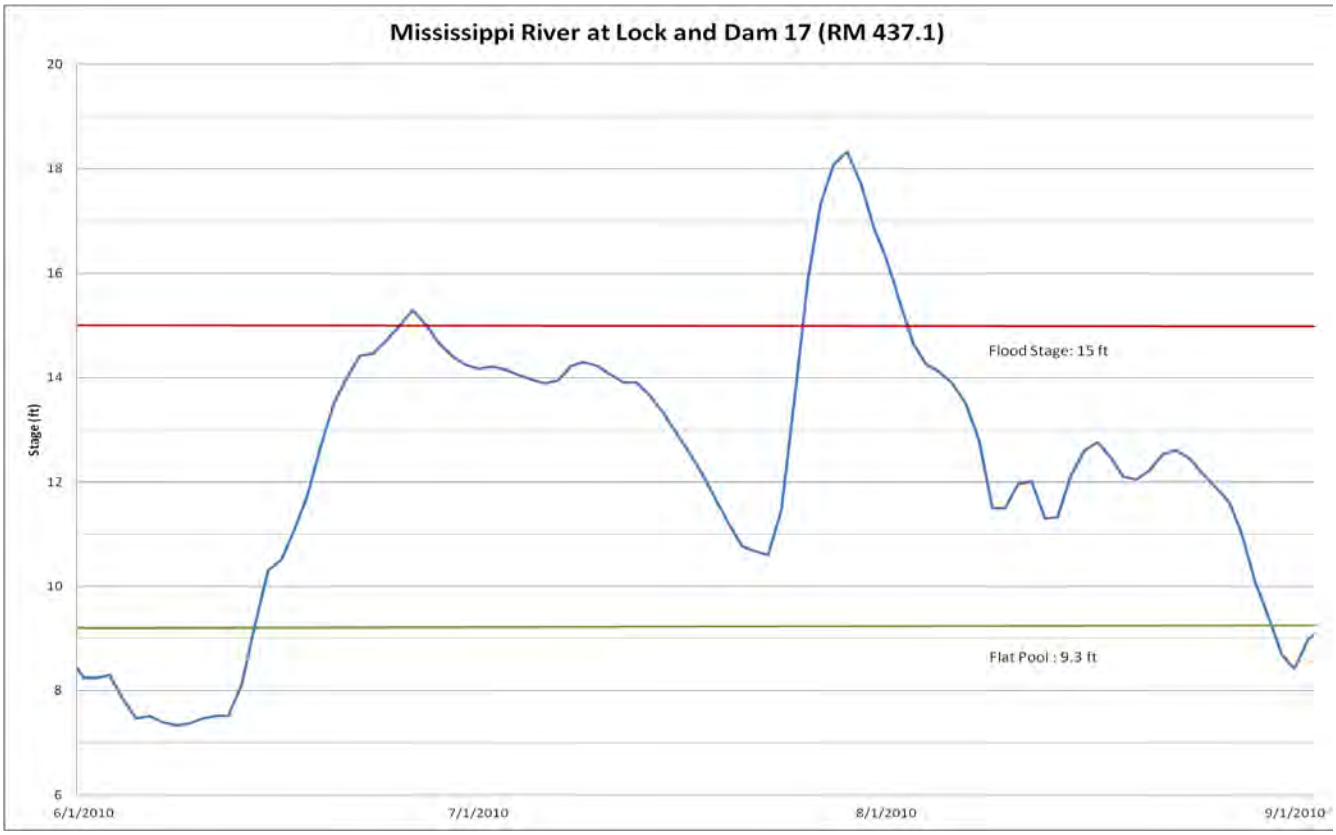
	Pre-Project Construction	Post-Project Previously Evaluated	Post-Project Monitoring Update
	None Performed	11/07/95 - 07/06/05	05/31/06 - 09/08/10
Total Times DO Sampled:	0	109	37
Total Samples with DO Concentrations Below 5.0 mg/L:	NA	31 (28%)	12 (32%)
Number of Winter Samples:	NA	34	6
DO Concentrations Below 5.0 mg/L during Winter Sampling:		6 (18%)	1 (17%)
Number of Summer Samples:	NA	75	31
DO Concentrations Below 5.0 mg/L during Summer Sampling:		25 (33%)	11 (35%)
Minimum DO Concentration (mg/L)	NA	0.4	1.4
Maximum DO Concentration (mg/L)	NA	19.4	20.4
Average DO Concentration (mg/L)	NA	7.5	7.6

As identified in the DPR, one objective of the project is to maintain dissolved oxygen (DO) concentrations greater than or equal to 5 mg/L to improve aquatic habitat. Results from DO grab sample measurements from the most recent monitoring period show concentrations below the target in 14% of the grab samples at site W-M443.6G and 32% of grab samples at site W-M444.4H. A graphic summary of water quality grab sample results from this period is shown in Graphs 1 and 2 of Appendix A.

The pre-construction average DO concentration for site W-M443.6G was 10.5 mg/L, which only represents the summer sampling season since no winter sampling was performed. Pre-construction DO concentrations ranged from 0.6 mg/L to 19.7 mg/L, with 2 grab samples below the target DO value of 5.0 mg/L. During the current monitoring period of May 31st 2006 to September 8th 2010, the average DO concentrations at site W-M443.6G were 7.5 mg/L during the summer and 13.0 mg/L during the winter sampling season. Additionally, 4 of the 31 summer sampling results were below the DO target and 1 of 6 winter sampling events yielded a concentration below 5.0 mg/L. There are limited results from in-situ continuous monitoring to confirm or further investigate some of the low DO events. Typically, summer DO concentrations fluctuate daily, with daytime highs commonly above the 5.0 mg/L target and nighttime lows typically below the target. Photosynthetic activity primarily accounts for these diurnal fluctuations. Due to the fact that low DO concentrations were measured via grab samples at both sites on July 13th and 27th of 2010 and by examining continuous monitoring data for that period. Low algal counts and high suspended sediment due to continued high water during the summer of 2010 are likely contributing factors that led to this low DO event that lasted the whole 2 weeks (See graphs 1 and 2 on the following page).



Graph 1 shows DO, depth, and chlorophyll a at site 443.6G from 02 June 2010 to 24 August 2010.



Graph 2 shows the Mississippi River stage at L&D 17, 6.5 miles downstream of the 443.6G sampling site, from 01 June to 01 September 2010. Flood stage (15 ft) is denoted by the red line and flat pool (9.3 ft) is denoted by the green line.

As stated earlier, there was no pre-construction water quality monitoring performed at sampling site W-M444.4H of the Big Timber Refuge project. During the current monitoring period, the average DO concentration was 6.74 mg/L during the summer and 12.01 mg/L during the winter sampling season. Summer DO concentrations ranged from 1.37 mg/L to 13.05 mg/L, with 11 of the 31 samples below the 5.0 mg/L target. Winter sampling DO measurements ranged from 1.79 mg/L to 12.01 mg/L, with only 1 of the 6 readings falling below the minimum DO target. By examining both the grab samples and the in-situ continuous monitoring results, DO concentrations at site W-M444.4H seem to have stayed below the 5.0 mg/L threshold beyond the normal diurnal fluctuations during the periods of August 6th through 8th 2006, September 9th to 23rd 2008, and June 15th to August 24th 2010. As discussed previously for site W-M443.6G, low algal counts and high suspended sediment due to a persistent high water level could have been contributing factors in the 2010 low DO event. This was the only event at site W-M444.4H where the DO concentration stayed below 5.0 mg/L for longer than 2 weeks. As a general trend, DO concentrations observed during both the summer and the winter sampling seasons were higher at site W-M443.6G than those measured at site W-M444.4H.

6. Discussion and Conclusions: The water quality objective of the Big Timber Refuge project is to improve levels of DO during critical seasonal stress periods. Associated to this objective, the Big Timber Refuge project aims to increase fish habitat in the backwater area off Coolegar Slough and to increase overwintering fish habitat. The target was to maintain a DO concentration greater than or equal to 5 mg/L, particularly during critical seasonal stress periods. Extreme seasonal conditions led to winter and summer fish kills in the project area, typically attributable to low dissolved oxygen levels over an extended period of time, as well as to fish becoming stranded or concentrated in unconnected waters once flood waters recede.

Graph 3 of Appendix A illustrates DO concentrations over the life of the project at monitoring site W-M443.6G. In comparing pre- and post-construction average DO concentrations since the Big Timber Refuge project's dredging was completed in the fall of 1991, there appears to be no distinct trend in DO concentrations. When looking at the grab sample results, there appears to be a slight decrease the first couple of years post project completion, followed by approximately 10 years of improved DO values during the previous reporting period. However during the current monitoring period of 31 May 2006 to 8 September 2010, grab sample results seem to indicate a slight decrease, especially during the high water and low DO event in the summer of 2010. Part of the reason for the average DO value decline during this monitoring period is the long flood season of 2010, which saw low DO values which could be partially attributable to high water levels, low algal driven photosynthesis, and high suspended sediment loads. Even though average DO concentrations started to decrease during this monitoring period, generally there was little potential for negative impacts to aquatic biota since continuous monitoring data indicates that most of the low DO events where values dropped below 5.0 mg/L were of short duration. According to the Iowa DNR (via a conversation between Nathan Richards of USACE and the IA DNR in November of 2013), no fish kill information is available to help assess potential impacts to fish as a result of the low DO events that occurred during this monitoring period, especially during the critical winter and summer seasons identified in the Big Timber project's DPR.

Post-project water quality monitoring commenced in November of 1995 at site W-M444.4H, and no pre-construction monitoring was performed. See Graph 4 of Appendix A for an illustration of average DO concentrations since project completion at monitoring site W-M444.4H. Similar to site W-M443.6G,

grab sample results seem to indicate a DO increase for approximately the first 5 years following project completion. The DO concentration peaked at 20.4 mg/L in March of 2010, and then ranged between 3.1 and 6.3 mg/L through the summer of 2010. For this monitoring period which concluded in September 2010, the average DO concentration was 7.6 mg/L.

In general, results from the current evaluation period indicate that the Big Timber Refuge project has not been effective at providing sufficient DO concentrations to meet the project objective identified in Section 4 of the Big Timber DPR of maintaining a dissolved oxygen concentration greater than or equal to 5 mg/L. On several occasions at both sites (during both the winter and summer seasons), the target level of 5.0 mg/L was not met, with some low DO events lasting for several consecutive days. The summer season had more occasions where DO dropped below the 5.0 mg/L target than the winter. This trend is most noticeable at site M444.4H where 35% of the summer grab sample results indicated low DO as opposed to 17% of the winter sampling results. Continued sedimentation and decreased water depths in backwater areas appear to have already reduced the effectiveness of the project to produce the water quality objectives. See pages 11-15 of the 2013 Big Timber Refuge PER for further information regarding sedimentation rates and water depth.

7. References:

Definite Project Report with Integrated Environmental Assessment (R-5), Big Timber Refuge Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 17, Upper Mississippi River, Louisa County, Iowa, July 1989.

Post-Construction Performance Evaluation Report – Year 9 (2000), Big Timber Refuge Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 17, Mississippi River Miles 443.5 – 445, Louisa County, Iowa, June 2001.

Post-Construction Performance Evaluation Report – Year15 (2006), Big Timber Refuge Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 17, Mississippi River Miles 443.5 – 445, Louisa County, Iowa, June 2007.

BIG TIMBER REFUGE
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FEBRUARY 2012

APPENDIX A

PLATES AND GRAPHS

Big Timber Refuge

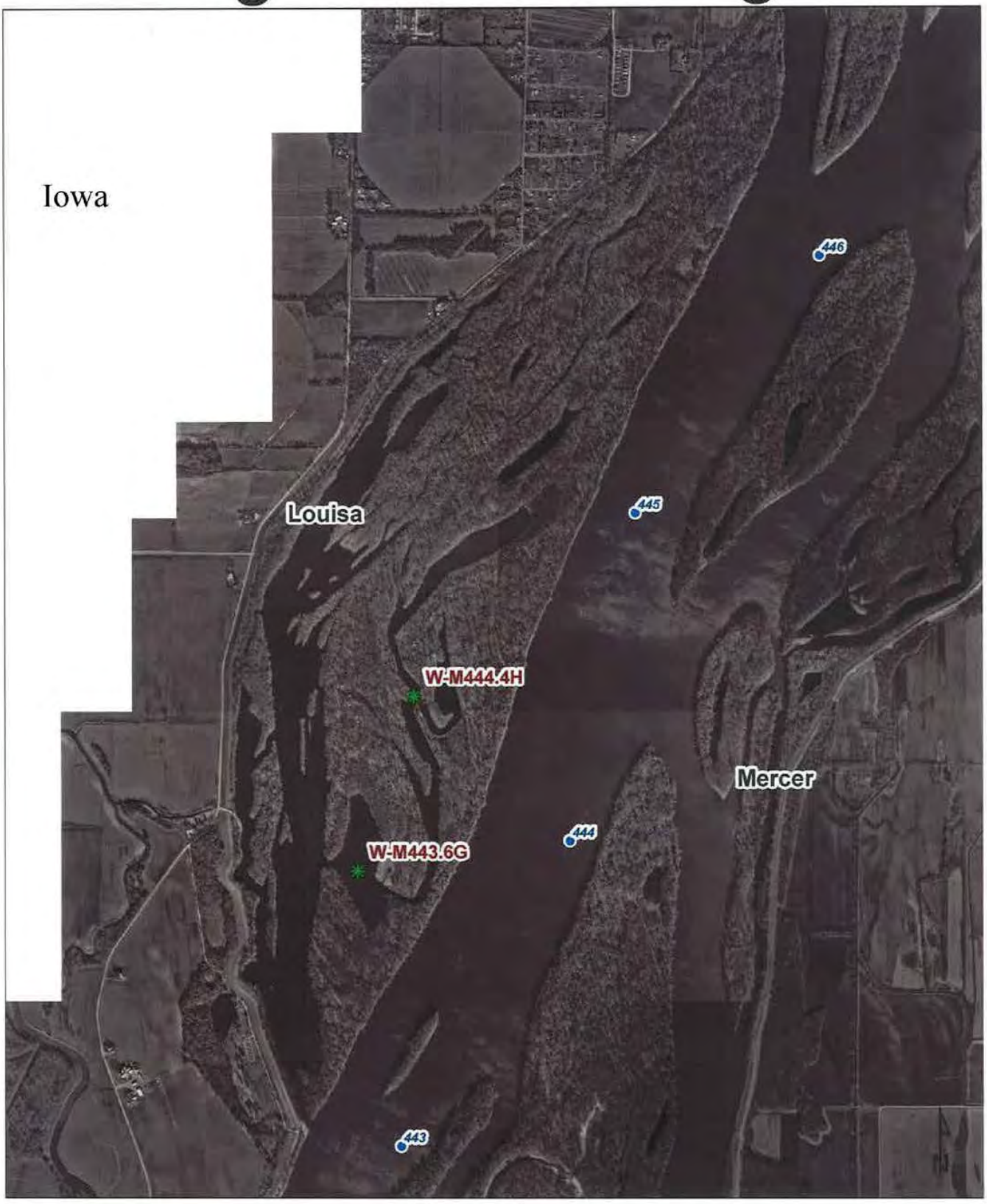
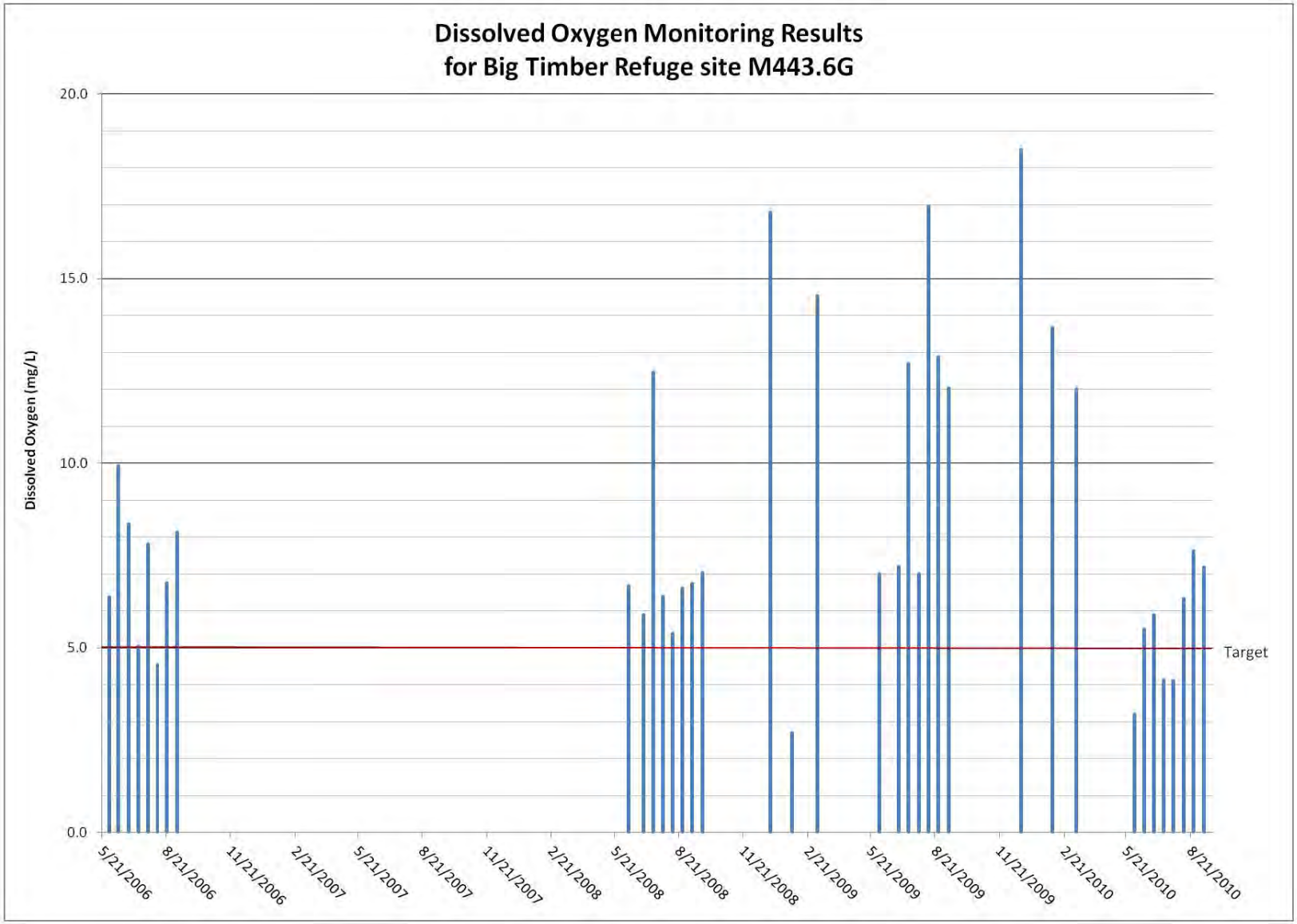
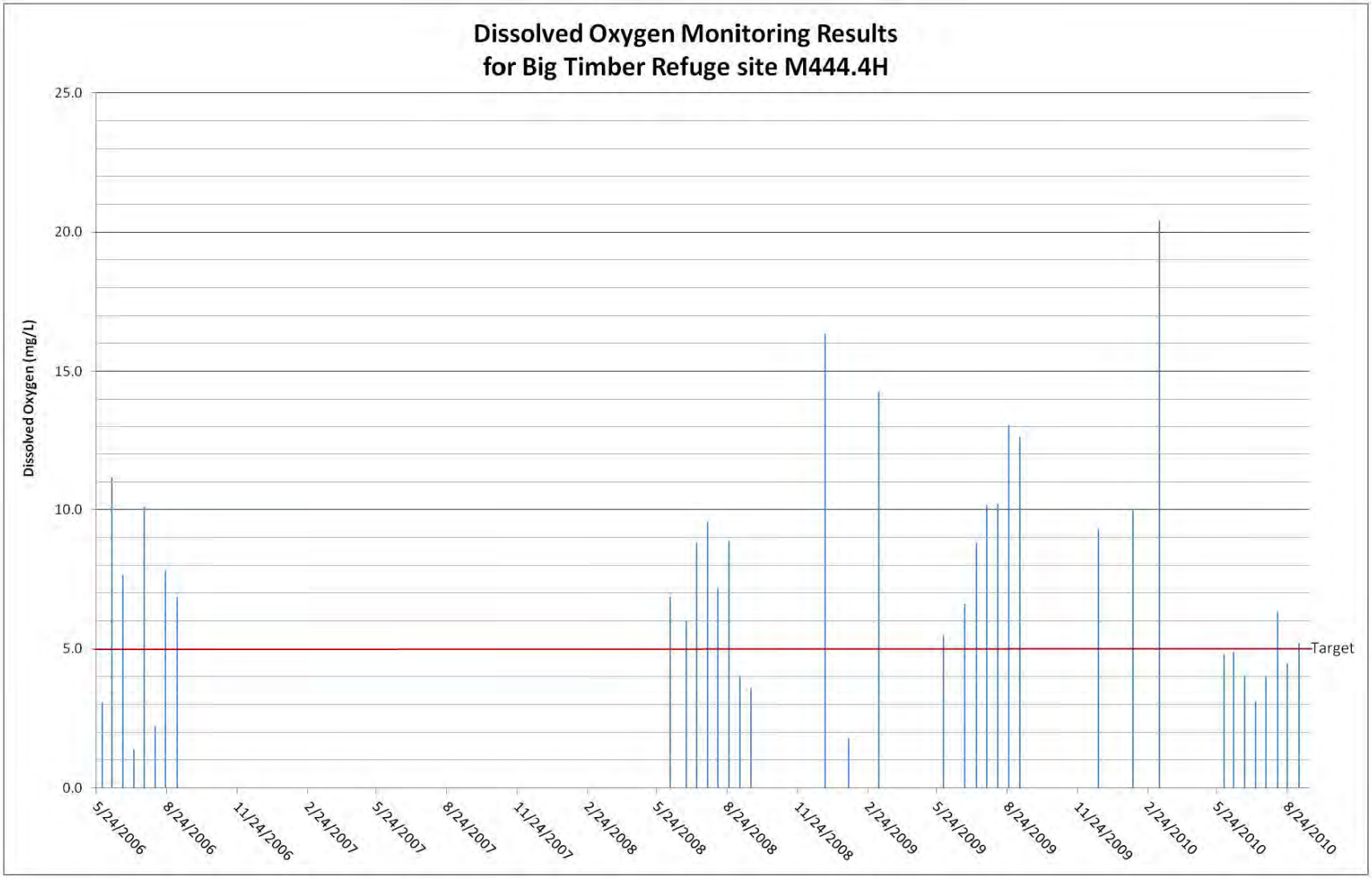


Plate 1



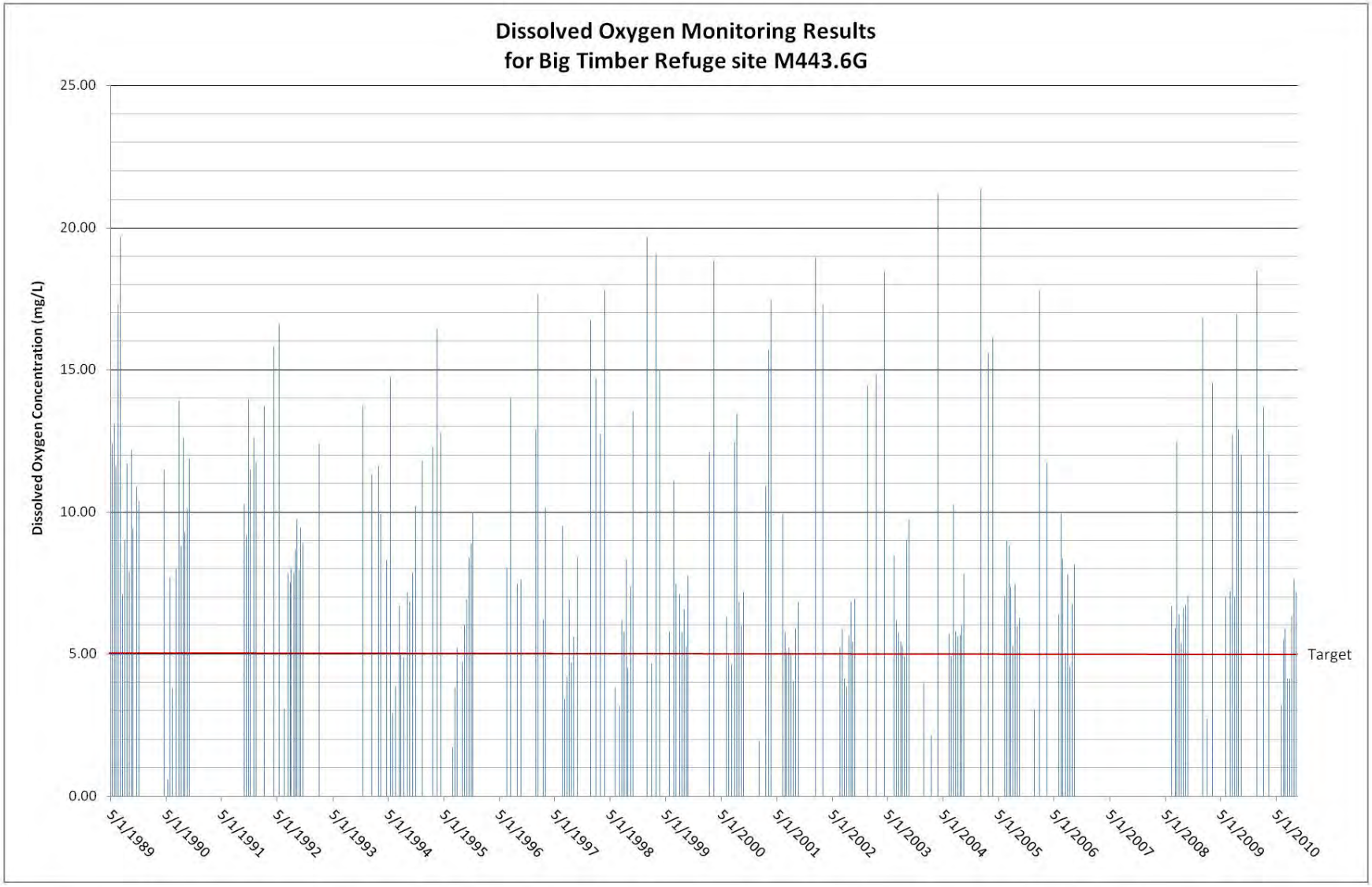
GRAPH 1

Graph 1 illustrates the dissolved oxygen concentrations (mg/L) at site M443.6G from 31 May 2006 to 8 September 2010. Due to the cyclical nature of EMP water quality monitoring, no data is available from 6 September 2006 to 10 June 2008.



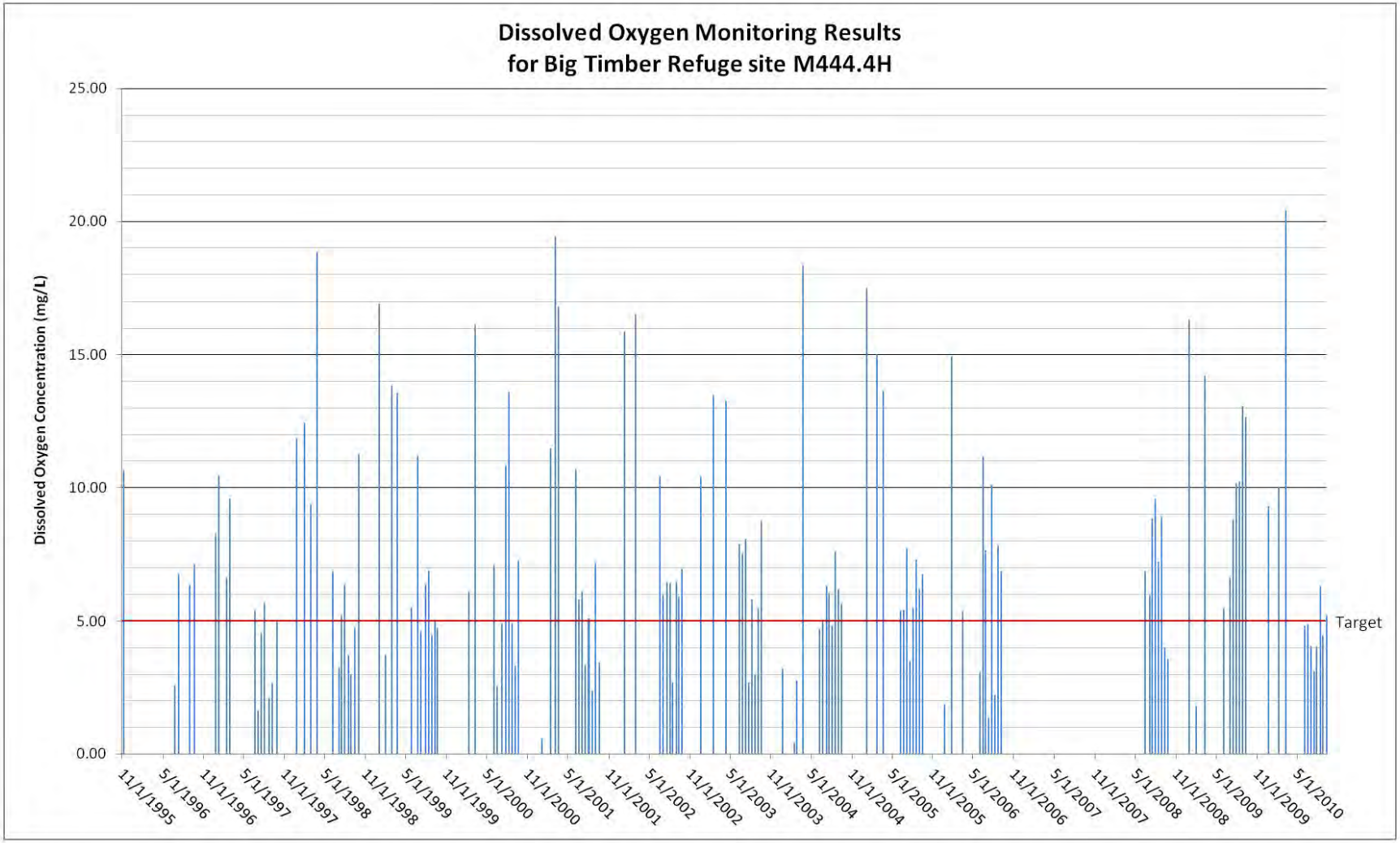
GRAPH 2

Graph 2 illustrates the dissolved oxygen concentrations (mg/L) at site M444.4H from 31 May 2006 to 8 September 2010. Due to the cyclical nature of EMP water quality monitoring, no data is available from 6 September 2006 to 10 June 2008.



GRAPH 3

Graph 3 illustrates previously reported grab sample results for dissolved oxygen concentration (mg/L) at site W-M443.6G from 6 May 1989 to 8 Sep 2010. Due to the cyclical nature of EMP water quality monitoring, no data is available from 6 Sep 2006 to 10 Jun 2008.



Graph 4 illustrates previously reported grab sample results for dissolved oxygen concentration (mg/L) at site W-M444.4H from 7 Nov 1995 to 8 Sep 2010. Due to the cyclical nature of EMP water quality monitoring, no data is available from 6 Sep 2006 to 10 Jun 2008.

GRAPH 4

BIG TIMBER REFUGE
POST-CONSTRUCTION
PERFORMANCE EVALUATION REPORT

WATER QUALITY ANALYSIS
FEBRUARY 2013

APPENDIX B

WATER QUALITY MONITORING
GRAB SAMPLE RESULTS

Pre-Project Monitoring Results at Station W-M443.6G
06 May 89 to 29 Sep 90

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
5/6/1989	0.50	-	12	12.4	8.8	160
5/20/1989	0.82	-	22	13.1	8.9	125
6/3/1989	0.69	-	25	11.6	8.7	76
6/17/1989	0.51	-	25	17.3	9.0	130
7/1/1989	0.62	-	31	19.7	9.2	195
7/15/1989	0.62	-	21	7.1	7.9	60
7/29/1989	0.46	-	29	9.0	8.1	26
8/12/1989	0.59	-	29	11.7	8.6	46
8/26/1989	0.49	-	27	7.9	8.4	28
9/9/1989	0.87	-	22	12.2	8.6	160
9/23/1989	0.69	-	16	9.4	8.3	33
10/14/1989	0.46	-	20	10.9	8.6	15
10/28/1989	0.61	-	16	10.4	8.1	21
4/14/1990	0.60	-	9	11.5	8.6	35
5/8/1990	0.60	<7.62	22	0.6	9.2	26
5/26/1990	1.20	<7.62	17	7.7	7.6	17
6/9/1990	0.69	<3.44	22	3.8	7.6	6
6/30/1990	1.02	<3.44	27	8.0	7.7	34
7/20/1990	0.46	<3.44	30	13.9	8.3	84
8/4/1990	0.61	<3.44	27	8.8	7.9	81
8/18/1990	0.67	<3.44	32	12.6	8.2	129
9/1/1990	-	-	30	9.3	8.0	13
9/15/1990	1.44	<3.44	25	10.1	8.1	69
9/29/1990	1.38	<3.44	19	11.9	8.5	49

Summer:	Min	0.46	<3.44	9	0.6	7.6	6
	Max	1.44	<7.62	32	19.7	9.2	195
	Ave	0.72	NA	23	10.5	NA	67
	Samples	23	9	24	24	24	24
Winter	Min	NA	NA	NA	NA	NA	NA
	Max	NA	NA	NA	NA	NA	NA
	Ave	NA	NA	NA	NA	NA	NA
	Samples	NA	NA	NA	NA	NA	NA
Overall	Min	0.46	<3.44	9	0.6	7.6	6
	Max	1.44	<7.62	32	19.7	9.2	195
	Ave	0.72	NA	23	10.5	NA	67
	Samples	23	9	24	24	24	24

Post-Project Monitoring Results at Station W-M443.6G
24 Sep 91 to 16 Mar 06

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
9/24/1991	3.05	4.97	16	10.3	8.9	24
10/10/1991	2.77	3.11	15	9.2	8.6	20
10/22/1991	2.68	3.29	15	14.0	8.6	49
11/5/1991	3.08	1.77	3	11.5	8.2	12
11/26/1991	3.66	2.23	3	12.6	-	6
12/13/1991	3.70	2.23	2	11.7	7.6	3
2/3/1992	2.68	0.00	3	13.7	7.5	21
4/7/1992	3.52	-	14	15.8	8.8	40
5/12/1992	3.05	2.83	19	16.6	4.5	54
6/4/1992	2.74	0.00	23	-	8.6	35
6/16/1992	2.59	6.16	25	3.1	7.9	30
7/10/1992	2.77	4.05	-	7.8	8.3	69
7/22/1992	3.20	0.00	24	7.5	7.7	42
7/27/1992	2.93	0.00	28	8.0	8.7	77
8/12/1992	2.82	3.44	25	7.8	8.3	58
8/25/1992	2.59	2.44	28	8.7	8.4	20
8/31/1992	1.86	0.00	26	9.8	9.0	25
9/15/1992	2.90	0.00	24	8.0	8.5	96
9/28/1992	3.23	8.53	18	9.4	8.0	33
10/13/1992	2.87	0.00	13	8.9	8.1	12
11/24/1992	3.83	2.07	5	-	8.0	10
1/25/1993	3.32	0.00	1	12.4	8.2	22
11/10/1993	2.53	2.29	5	13.7	8.9	36
1/10/1994	2.74	0.00	2	11.3	8.2	12
2/24/1994	3.78	1.22	0	11.6	7.8	6
3/9/1994	3.58	0.00	3	9.9	7.9	-
4/19/1994	2.74	2.68	16	8.3	8.3	67
5/10/1994	3.87	3.81	16	14.7	8.7	60
5/24/1994	2.76	1.13	23	2.9	7.5	21
6/14/1994	2.55	4.27	27	3.8	7.6	26
7/7/1994	2.61	0.00	28	6.7	8.0	40
7/19/1994	2.44	6.16	27	5.0	8.0	32
8/9/1994	2.29	-	25	4.9	8.3	46
8/30/1994	2.35	1.25	23	7.2	8.4	27
9/13/1994	2.13	3.26	24	6.8	8.5	57
10/4/1994	2.53	1.28	17	7.9	8.3	36
10/25/1994	2.38	3.63	12	10.2	9.2	39
12/6/1994	2.44	2.19	4	11.8	8.6	9
1/11/1995	-	-	-	-	-	-
2/14/1995	2.57	2.13	3	12.3	8.2	20
3/14/1995	2.18	0.00	10	16.4	8.9	57
4/11/1995	3.05	2.47	8	12.8	9.5	140
5/2/1995	-	-	-	-	-	-
5/16/1995	-	-	-	-	-	-
6/13/1995	2.96	1.34	22	-	8.0	58
6/27/1995	2.48	0.00	26	1.7	7.7	43
7/11/1995	1.95	2.13	28	3.8	8.0	100
7/25/1995	2.38	0.00	28	5.2	8.3	82
8/29/1995	2.50	0.00	29	4.7	8.2	33
9/12/1995	2.29	0.00	20	6.0	7.9	32
9/27/1995	2.10	0.64	16	6.9	-	23
10/10/1995	2.68	0.00	16	8.4	8.2	-
10/24/1995	2.33	-	9	8.9	8.4	111
11/7/1995	2.82	6.80	28	10.0	7.8	58

Post-Project Monitoring Results at Station W-M443.6G
24 Sep 91 to 16 Mar 06 (Continued 1)

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
6/19/1996	2.74	3.99	23	8.0	7.7	-
7/10/1996	2.85	0.00	25	14.0	8.6	75
8/13/1996	2.16	7.92	-	-	-	65
8/27/1996	0.91	1.52	27	7.5	-	45
9/19/1996	1.92	5.79	19	7.6	8.4	42
12/23/1996	2.18	0.00	3	12.9	8.1	8
1/7/1997	2.10	0.00	4	17.6	-	44
2/11/1997	2.07	0.00	1	6.2	-	44
2/25/1997	44.00	44.00	1	10.2	-	44
6/18/1997	2.26	3.41	25	9.5	8.5	44
7/2/1997	4.33	-	29	3.4	7.9	100
7/17/1997	2.10	2.38	28	4.2	7.9	92
7/31/1997	2.29	0.00	26	6.9	8.3	120
8/19/1997	2.07	2.26	23	4.7	7.7	44
9/3/1997	2.04	3.99	23	5.6	7.9	44
9/25/1997	1.98	0.00	19	8.4	8.3	50
12/23/1997	1.86	0.00	2	16.8	-	17
1/27/1998	1.68	0.00	2	14.7	8.3	5
2/24/1998	2.07	-	7	12.7	8.5	11
3/24/1998	2.41	0.00	6	17.8	8.1	56
6/3/1998	2.04	7.86	22	3.8	7.5	59
7/2/1998	3.44	5.82	27	3.2	7.3	10
7/14/1998	3.11	0.00	27	6.2	7.5	12
7/28/1998	1.97	0.00	28	5.8	7.9	72
8/13/1998	1.92	0.00	27	8.3	8.4	70
8/25/1998	1.83	2.07	27	4.5	7.9	52
9/10/1998	1.75	1.95	22	7.4	8.2	54
9/29/1998	1.87	0.00	26	13.5	8.6	65
12/29/1998	1.83	0.00	3	19.7	8.7	17
1/28/1999	1.83	0.00	2	4.7	7.7	8
2/25/1999	1.83	0.00	4	19.1	9.0	25
3/23/1999	1.98	0.00	8	15.0	9.0	34
5/27/1999	4.54	0.00	19	5.8	6.7	<1
6/22/1999	2.68	1.65	25	11.1	8.2	49
7/8/1999	1.83	1.62	28	7.5	8.2	80
7/27/1999	2.90	3.87	30	7.1	8.1	34
8/10/1999	1.92	4.42	25	5.8	7.7	68
8/24/1999	1.77	2.90	23	6.6	8.2	64
9/8/1999	1.68	0.00	23	5.2	8.2	42
9/21/1999	1.81	0.00	15	7.7	8.5	32
2/8/2000	1.30	0.00	2	12.1	7.9	11
3/7/2000	2.10	0.00	12	18.8	8.9	94
5/31/2000	1.97	-	20	6.3	7.8	40
6/15/2000	4.12	-	23	5.0	7.5	6
7/6/2000	2.87	-	25	4.6	7.5	10
7/25/2000	1.83	-	25	12.5	8.3	54
8/8/2000	1.79	-	29	13.4	8.8	19
8/22/2000	1.97	-	24	6.8	8.3	60
9/5/2000	1.71	-	21	6.0	7.9	59
9/19/2000	1.76	-	20	7.2	8.5	71
1/3/2001	1.70	-	0	1.9	7.5	4
2/13/2001	1.98	-	1	10.9	7.7	3
3/6/2001	1.79	0.00	2	15.7	8.3	39
3/20/2001	1.97	0.00	4	17.5	8.9	21
6/5/2001	3.37	0.85	17	9.9	7.9	24
6/19/2001	2.96	0.00	24	5.8	7.6	47
7/3/2001	3.04	-	25	5.1	7.5	6

Post-Project Monitoring Results at Station W-M443.6G
24 Sep 91 to 16 Mar 06 (Continued 2)

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
7/18/2001	1.62	-	28	5.2	7.9	50
7/31/2001	1.80	-	29	5.0	8.1	54
8/14/2001	1.55	0.00	26	4.0	7.9	70
8/28/2001	1.59	-	25	5.9	8.2	44
9/18/2001	1.64	0.00	19	6.8	8.2	72
1/8/2002	1.72	0.00	3	19.0	8.1	10
2/28/2002	1.85	0.00	2	17.3	8.3	36
6/18/2002	2.35	-	22	5.2	7.4	19
7/2/2002	2.39	-	29	5.9	7.7	62
7/18/2002	1.60	-	28	4.1	7.7	99
8/1/2002	1.55	-	29	3.9	7.7	56
8/14/2002	1.72	0.00	23	5.6	7.8	70
8/29/2002	1.48	-	26	6.8	8.1	37
9/10/2002	1.50	1.86	27	5.4	8.1	54
9/24/2002	1.50	-	16	6.9	8.2	49
12/17/2002	1.52	-	3	14.4	8.7	-
2/13/2003	1.46	0.30	2	14.8	8.4	-
4/10/2003	1.57	1.89	7	18.5	9.2	-
6/10/2003	1.62	-	21	8.5	8.2	88
6/24/2003	1.52	-	26	6.2	7.7	91
7/8/2003	2.71	1.69	29	5.8	8.1	77
7/22/2003	1.75	-	25	5.4	8.2	80
8/5/2003	1.31	0.70	26	5.3	8.5	85
8/19/2003	1.49	-	27	4.9	8.4	52
9/2/2003	1.32	0.59	21	9.0	8.3	155
9/16/2003	1.28	3.58	21	9.8	8.6	120
12/23/2003	1.42	1.14	1	4.0	7.8	-
2/12/2004	1.36	0.43	0	2.1	7.6	-
3/23/2004	1.39	-	7	21.2	9.4	-
6/8/2004	3.94	-	23	5.7	7.2	3
6/22/2004	4.35	8.33	22	4.9	7.2	<1
7/7/2004	1.63	2.99	23	10.3	8.1	89
7/20/2004	1.70	2.25	27	5.8	7.9	65
8/3/2004	1.42	3.59	26	5.6	7.9	73
8/17/2004	1.42	1.43	22	5.7	8.1	81
8/31/2004	1.44	2.14	23	6.0	7.9	50
9/14/2004	1.45	-	23	7.8	8.6	44
1/4/2005	1.43	0.59	4	21.3	8.7	32
2/22/2005	1.64	-	2	15.6	8.2	13
3/22/2005	1.43	-	6	16.1	9.1	100
6/8/2005	1.84	-	26	7.0	8.3	94
6/21/2005	1.65	0.41	27	9.0	8.4	130
7/6/2005	1.55	0.78	26	8.8	8.6	92
7/19/2005	1.38	0.45	28	7.4	8.4	74
8/2/2005	1.31	0.35	27	5.3	8.2	64
8/17/2005	1.33	1.75	26	7.5	8.4	50
8/30/2005	1.39	1.09	26	6.0	8.4	48
9/13/2005	1.32	3.50	25	6.3	8.5	62
12/22/2005	1.48	0.40	1	3.0	7.3	46
1/25/2006	1.40	-	0	17.8	8.9	110
3/16/2006	1.51	-	9	11.7	8.1	26

Summer:	Min	0.91	0.00	8	1.7	4.5	3
	Max	4.54	8.53	30	16.6	9.5	155
	Ave	2.26	2.08	23	7.2	NA	56
	Samples	113	84	111	110	110	109
Winter	Min	1.30	0.00	0	1.9	7.3	3
	Max	44.00	44.00	28	21.3	9.4	110
	Ave	3.06	1.94	4	13.3	NA	29
	Samples	46	37	46	45	41	39
Overall	Min	0.91	0.00	0	1.7	4.5	3
	Max	44.00	44.00	30	21.3	9.5	155
	Ave	2.49	2.04	18	9.0	NA	49
	Samples	159	121	157	155	151	148

Post-Project Monitoring Results at Station W-M443.6G
31 May 06 to 08 Sep 10

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
5/31/2006	1.65	0.37	26	6.4	8.1	210
6/13/2006	1.39	0.77	22	9.9	8.5	130
6/27/2006	1.34	-	23	8.4	8.5	240
7/11/2006	1.40	3.39	27	5.0	8.3	90
7/25/2006	1.05	0.68	27	7.8	8.6	110
8/8/2006	1.40	4.20	26	4.6	8.4	86
8/22/2006	1.24	1.47	25	6.8	8.7	92
9/6/2006	1.07	0.39	22	8.1	8.6	68
6/10/2008	3.34	6.72	24	6.7	7.8	7
7/1/2008	3.35	1.95	24	5.9	7.6	6
7/15/2008	2.19	1.26	26	12.5	8.5	110
7/29/2008	1.25	3.01	27	6.4	7.8	97
8/12/2008	1.16	0.92	24	5.4	8.1	88
8/26/2008	1.14	3.79	23	6.6	8.5	55
9/9/2008	1.20	1.02	18	6.7	-	29
9/23/2008	1.13	0.92	22	7.0	-	37
12/29/2008	2.03	2.11	0	16.8	8.1	-
1/29/2009	1.29	0.57	1	2.7	7.4	-
3/6/2009	1.98	10.61	4	14.5	7.8	-
6/2/2009	1.39	2.27	21	7.0	8.2	90
6/16/2009	1.36	1.33	23	-	8.4	133
6/30/2009	1.19	1.30	24	7.2	8.4	64
7/14/2009	1.22	2.64	25	12.7	8.8	114
7/28/2009	1.13	2.40	27	7.0	8.4	108
8/11/2009	1.36	2.47	28	17.0	9.0	153
8/25/2009	1.16	6.82	26	12.9	8.9	93
9/9/2009	1.16	0.52	25	12.0	8.8	114
12/21/2009	1.11	0.55	3	18.5	8.5	-
2/4/2010	1.33	2.12	1	13.7	7.5	-
3/10/2010	1.22	5.66	1	12.0	7.9	-
6/2/2010	1.41	0.58	26	3.2	7.9	96
6/15/2010	1.64	-	25	5.5	7.9	46
6/29/2010	3.01	-	26	5.9	7.9	45
7/13/2010	1.87	-	26	4.1	7.6	29
7/27/2010	4.27	-	28	4.1	7.5	7
8/11/2010	2.28	-	27	6.3	7.7	31
8/24/2010	2.34	-	26	7.6	7.8	38
9/8/2010	1.12	-	20	7.2	8.0	53

Summer:	Min	1.05	0.37	18	3.2	7.5	6
	Max	4.27	6.82	28	17.0	9.0	240
	Ave	1.66	2.13	25	7.5	NA	83
	Samples	32	24	32	31	30	32
Winter	Min	1.11	0.55	0	2.7	7.4	NA
	Max	2.03	10.61	4	18.5	8.5	NA
	Ave	1.49	3.60	2	13.0	NA	NA
	Samples	6	6	6	6	6	0
Overall	Min	1.05	0.37	0	2.7	7.4	6
	Max	4.27	10.61	28	18.5	9.0	240
	Ave	1.63	2.43	21	8.4	NA	83
	Samples	38	30	38	37	36	32

Post-Project Monitoring Results at Station W-M444.4
7 Nov 95 to 16 Mar 06

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
11/7/1995	1.65	5.43	5	10.7	8.3	23
6/19/1996	2.26	0.00	23	2.6	7.6	28
7/10/1996	2.62	0.00	26	6.7	7.9	100
8/13/1996	2.13	6.25	-	-	-	52
8/27/1996	1.28	2.50	27	6.4	-	195
9/19/1996	0.62	-	21	7.1	7.9	49
12/23/1996	2.18	0.00	3	8.3	-	16
1/7/1997	2.09	0.00	4	10.5	-	52
2/11/1997	2.13	0.00	1	6.6	-	67
2/25/1997	3.95	0.00	2	9.6	-	<1
6/18/1997	2.13	2.74	26	5.4	8.0	130
7/2/1997	2.13	2.80	30	1.6	7.9	69
7/17/1997	2.13	4.42	29	4.6	7.9	140
7/31/1997	2.32	0.00	26	5.7	7.9	80
8/19/1997	2.10	2.47	24	2.1	7.5	36
9/3/1997	2.04	4.39	25	2.7	7.6	24
9/25/1997	2.07	4.69	19	5.0	7.8	22
12/23/1997	1.83	0.00	4	11.8	-	24
1/27/1998	1.89	0.00	3	12.4	7.7	32
2/24/1998	2.13	-	7	9.4	7.8	12
3/24/1998	2.21	0.76	7	18.8	8.4	95
6/3/1998	1.98	3.32	22	6.8	7.5	35
7/2/1998	3.73	0.00	27	3.3	7.3	10
7/14/1998	3.19	1.58	28	5.2	7.4	13
7/28/1998	1.98	0.00	28	6.4	7.9	51
8/13/1998	2.01	0.00	27	3.7	7.7	64
8/25/1998	1.92	0.00	28	3.0	7.7	62
9/10/1998	1.78	2.44	23	4.7	7.7	82
9/29/1998	1.87	1.55	25	11.3	8.3	78
12/29/1998	1.94	0.00	4	16.9	8.8	28
1/28/1999	2.04	0.00	0	3.7	7.6	7
2/25/1999	1.91	0.00	3	13.8	8.5	31
3/23/1999	2.13	0.00	9	13.6	8.9	48
5/27/1999	4.51	3.57	18	5.5	7.2	3
6/22/1999	2.74	2.32	25	11.2	8.2	33
7/8/1999	2.13	-	28	4.6	8.1	56
7/27/1999	3.02	0.00	30	6.4	8.1	28
8/10/1999	2.07	5.00	26	6.9	7.7	67
8/24/1999	2.07	-	24	4.5	7.8	65
9/8/1999	1.80	0.00	25	5.0	8.0	77
9/21/1999	1.98	0.00	18	4.7	8.0	36
2/8/2000	1.86	0.00	1	6.1	7.5	9
3/7/2000	2.15	3.51	12	16.1	8.7	100
5/31/2000	2.05	-	20	7.1	8.0	48
6/15/2000	4.22	-	23	2.6	7.4	6
7/6/2000	3.02	-	25	4.9	7.5	20
7/25/2000	1.91	-	25	10.8	7.9	80
8/8/2000	1.78	-	30	13.6	8.5	19
8/22/2000	2.01	-	25	4.9	7.7	36
9/5/2000	1.74	-	24	3.3	7.8	45
9/19/2000	1.80	-	21	7.3	8.5	70

Post-Project Monitoring Results at Station W-M444.4
7 Nov 95 to 16 Mar 06 (Continued)

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
1/3/2001	1.84	-	1	0.6	7.5	4
2/13/2001	2.10	-	1	11.5	7.7	36
3/6/2001	1.89	0.00	2	19.4	8.5	37
3/20/2001	2.04	0.00	4	16.8	9.0	18
6/5/2001	3.75	0.00	17	10.7	8.1	27
6/19/2001	3.05	1.58	24	5.8	7.6	57
7/3/2001	3.51	0.00	26	6.1	7.6	8
7/18/2001	1.85	-	28	3.4	7.6	52
7/31/2001	1.87	0.00	30	5.1	8.0	68
8/14/2001	1.69	0.00	25	2.4	7.8	78
8/28/2001	1.67	0.00	26	7.2	8.2	172
9/18/2001	1.76	0.00	19	3.4	7.9	160
1/8/2002	1.85	0.00	4	15.9	8.1	15
2/28/2002	1.93	-	4	16.5	8.2	33
6/18/2002	2.69	-	22	10.4	7.8	104
7/2/2002	2.60	-	29	6.0	7.7	45
7/18/2002	1.85	3.17	29	6.5	7.9	167
8/1/2002	1.85	-	30	6.4	8.0	125
8/14/2002	1.98	-	25	2.7	7.4	35
8/29/2002	1.99	-	26	6.5	7.9	59
9/10/2002	1.75	0.00	27	5.9	7.9	91
9/24/2002	1.65	-	17	6.9	8.2	56
12/17/2002	1.65	-	4	10.4	8.2	-
2/13/2003	1.70	0.39	2	13.5	8.1	-
4/10/2003	1.84	1.62	7	13.3	8.5	-
6/10/2003	1.78	-	22	7.9	7.9	111
6/24/2003	1.72	-	28	7.5	7.9	123
7/8/2003	2.12	2.14	30	8.0	8.4	168
7/22/2003	1.95	-	26	2.7	7.2	118
8/5/2003	1.53	1.35	26	5.8	8.3	185
8/19/2003	1.64	-	28	3.0	8.1	208
9/2/2003	1.41	1.65	22	5.5	7.7	230
9/16/2003	1.47	1.06	21	8.7	8.4	223
12/23/2003	1.58	0.22	2	3.2	7.8	-
2/12/2004	1.53	0.14	1	0.4	7.4	-
2/24/2004	-	-	2	2.7	7.6	-
3/23/2004	1.65	-	9	18.3	9.2	-
6/8/2004	4.33	-	23	4.7	7.0	<1
6/22/2004	4.76	2.79	22	5.0	7.1	<1
7/7/2004	1.74	1.14	24	6.3	7.3	81
7/20/2004	1.75	1.29	28	6.1	7.8	76
8/3/2004	1.57	1.14	26	4.8	7.7	58
8/17/2004	1.73	0.19	23	7.6	8.1	127
8/31/2004	1.45	1.01	23	6.2	7.9	70
9/14/2004	1.75	-	24	5.6	7.9	56
1/4/2005	1.72	0.75	4	17.5	8.5	13
2/22/2005	1.84	-	3	15.0	8.2	18
3/22/2005	1.69	-	7	13.6	8.9	56
6/8/2005	1.82	-	28	5.4	8.1	91
6/21/2005	1.84	1.04	27	5.4	8.3	110
7/6/2005	1.72	1.28	26	7.7	8.1	110

Post-Project Monitoring Results at Station W-M444.4
7 Nov 95 to 16 Mar 06 (Continued 2)

	DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
	7/19/2005	1.50	0.82	28	3.5	7.9	72
	8/2/2005	1.49	1.20	28	5.5	8.2	95
	8/17/2005	1.46	0.18	26	7.3	8.3	110
	8/30/2005	1.56	1.89	26	6.2	8.2	94
	9/13/2005	1.53	3.97	27	6.7	8.5	94
	12/22/2005	1.54	0.29	1	1.9	7.3	25
	1/25/2006	1.35	-	1	14.9	8.2	56
	3/16/2006	1.70	-	9	5.4	7.3	29
Summer:	Min	0.62	0.00	17	1.6	7.0	3
	Max	4.76	6.25	30	13.6	8.5	230
	Ave	2.14	1.55	25	5.8	NA	80
	Samples	76	51	75	75	74	74
Winter	Min	1.35	0.00	0	0.4	7.3	4
	Max	3.95	5.43	12	19.4	9.2	100
	Ave	1.92	0.57	4	11.1	NA	34
	Samples	33	23	34	34	29	27
Overall	Min	0.62	0.00	0	0.4	7.0	3
	Max	4.76	6.25	30	19.4	9.2	230
	Ave	2.07	1.24	18	7.5	7.9	68
	Samples	109	74	109	109	103	100

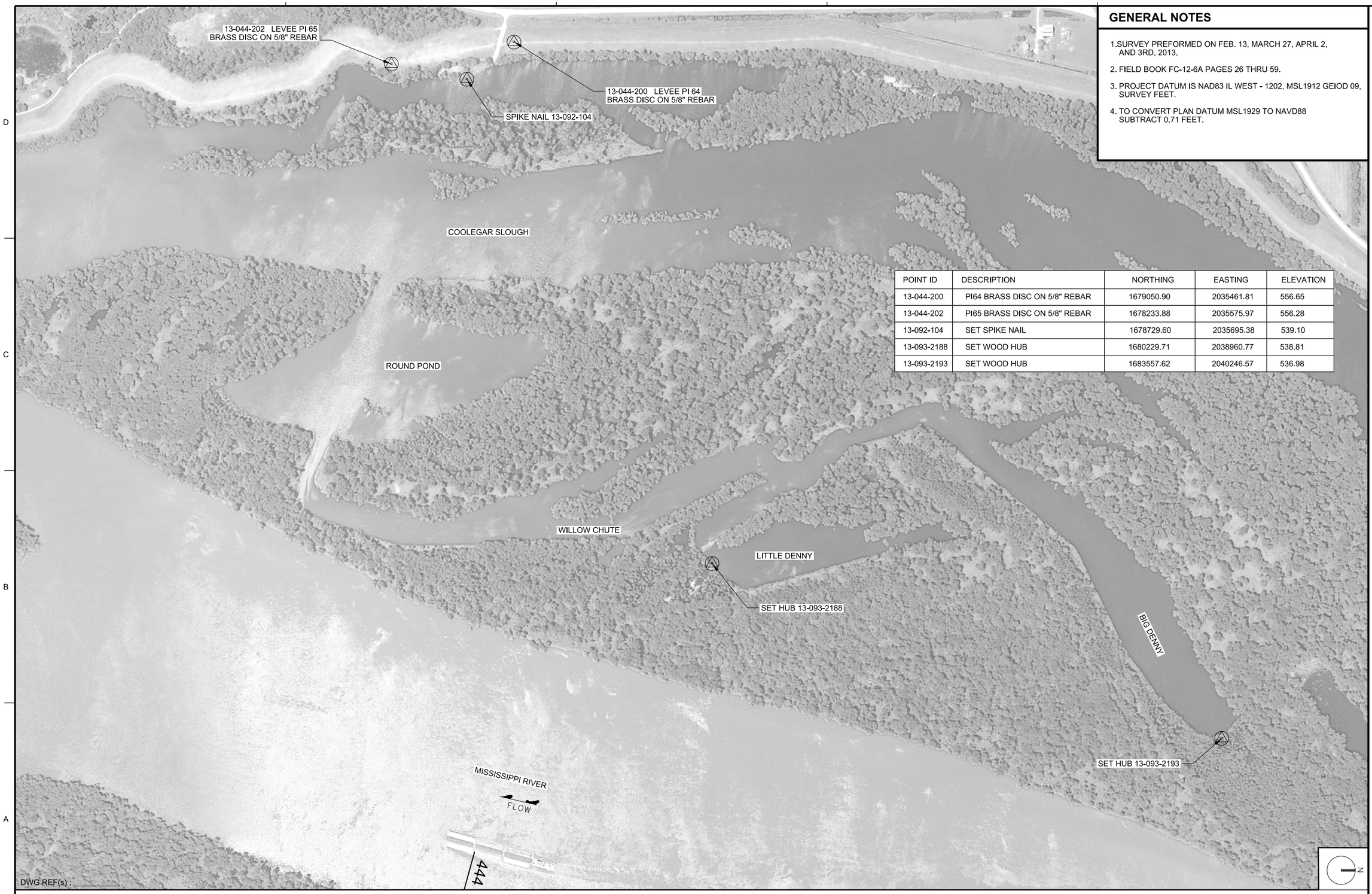
Post-Project Monitoring Results at Station W-M444.4
31 May 06 to 08 Sep 10

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
5/31/2006	1.85	2.01	26	3.1	7.7	200
6/13/2006	1.55	1.34	22	11.2	8.4	160
6/27/2006	1.50	1.33	24	7.7	8.2	170
7/11/2006	1.55	1.22	28	1.4	8.0	170
7/25/2006	1.49	0.99	28	10.1	8.8	180
8/8/2006	1.59	0.62	27	2.2	8.0	140
8/22/2006	1.43	0.21	25	7.8	8.7	220
9/6/2006	1.47	1.23	22	6.8	8.6	190
6/10/2008	3.90	2.59	25	6.8	7.8	13
7/1/2008	3.36	0.89	24	6.0	7.7	8
7/15/2008	2.43	2.74	27	8.8	8.2	120
7/29/2008	1.45	0.63	28	9.6	7.8	270
8/12/2008	1.38	1.07	25	7.2	8.0	510
8/26/2008	1.33	0.65	24	8.9	8.7	130
9/9/2008	1.43	1.94	19	4.0	-	140
9/23/2008	1.41	0.90	23	3.6	-	14
12/29/2008	2.11	0.74	0	16.3	8.1	-
1/29/2009	1.33	0.36	1	1.8	7.3	-
3/9/2009	2.49	1.88	5	14.2	7.8	-
6/2/2009	1.42	0.56	22	5.5	8.0	116
6/16/2009	1.52	1.02	24	-	8.0	109
6/30/2009	1.32	1.88	25	6.6	7.9	121
7/14/2009	1.40	0.46	26	8.8	8.2	120
7/28/2009	1.22	2.77	29	10.2	8.8	52
8/11/2009	1.47	1.36	28	10.2	8.8	121
8/25/2009	1.18	3.29	27	13.1	8.8	209
9/9/2009	1.28	2.24	25	12.6	8.6	216
12/21/2009	1.31	0.58	2	9.3	7.6	-
2/4/2010	1.41	0.61	1	10.0	7.2	-
3/10/2010	1.36	2.66	1	20.4	7.4	-
6/2/2010	1.47	2.13	26	4.8	7.8	82
6/15/2010	1.88	-	26	4.9	7.3	85
6/29/2010	3.22	-	25	4.0	7.6	66
7/13/2010	2.94	-	25	3.1	7.5	31
7/27/2010	4.52	-	27	4.0	7.4	5
8/11/2010	2.46	-	27	6.3	7.5	39
8/24/2010	2.39	-	26	4.5	7.4	25
9/8/2010	1.55	-	21	5.2	7.8	83

Summer:	Min	1.18	0.21	19	1.4	7.3	5
	Max	4.52	3.29	29	13.1	8.8	510
	Ave	1.89	1.44	25	6.7	NA	129
	Samples	32	25	32	31	30	32
Winter	Min	1.31	0.36	0	1.8	7.2	NA
	Max	2.49	2.66	5	20.4	8.1	NA
	Ave	1.67	1.14	2	12.0	NA	NA
	Samples	6	6	6	6	6	0
Overall	Min	1.18	0.21	0	1.4	7.2	5
	Max	4.52	3.29	29	20.4	8.8	510
	Ave	1.85	1.38	21	7.6	NA	129
	Samples	38	31	38	37	36	32

Appendix B

2013 Sediment Transect Plates



GENERAL NOTES

1. SURVEY PREFORMED ON FEB. 13, MARCH 27, APRIL 2, AND 3RD, 2013.
2. FIELD BOOK FC-12-6A PAGES 26 THRU 59.
3. PROJECT DATUM IS NAD83 IL WEST - 1202, MSL1912 GEIOD 09, SURVEY FEET.
4. TO CONVERT PLAN DATUM MSL1929 TO NAVD88 SUBTRACT 0.71 FEET.

POINT ID	DESCRIPTION	NORTHING	EASTING	ELEVATION
13-044-200	PI64 BRASS DISC ON 5/8" REBAR	1679050.90	2035461.81	556.65
13-044-202	PI65 BRASS DISC ON 5/8" REBAR	1678233.88	2035575.97	556.28
13-092-104	SET SPIKE NAIL	1678729.60	2035695.38	539.10
13-093-2188	SET WOOD HUB	1680229.71	2038960.77	538.81
13-093-2193	SET WOOD HUB	1683557.62	2040246.57	536.98

DWG REF(s) : _____

A1 SURVEY CONTROL PLAN
SCALE : 1"=300'-0" 0 300' 600'

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

DESIGNED BY: SJG
DWN BY: MLS
CKD BY:
SUBMITTED BY: HLA
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PLOT SCALE: 1
PLOT DATE:
AS SHOWN
SIZE: ANSI D
PROJECT CODE: PER
FILE NAME: PER-V101xxx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
SURVEY CONTROL PLAN

Sheet ID
V-101

A1 SITE PLAN

SCALE : 1"=400'-0" 0 400' 800'

SHEET NOTES

1. MAST TREES PLANTED ON CONTAINMENT DIKE.
2. DATE OF AERIAL PHOTOGRAPHY 2010

LEGEND

- SHALLOW AQUATIC HABITAT
- COMBINATION SHALLOW/DEEP AQUATIC HABITAT
- DEEP AQUATIC HABITAT
- EXCAVATED SIDECAST MATERIAL
- CHECK DAM

US Army Corps of Engineers®

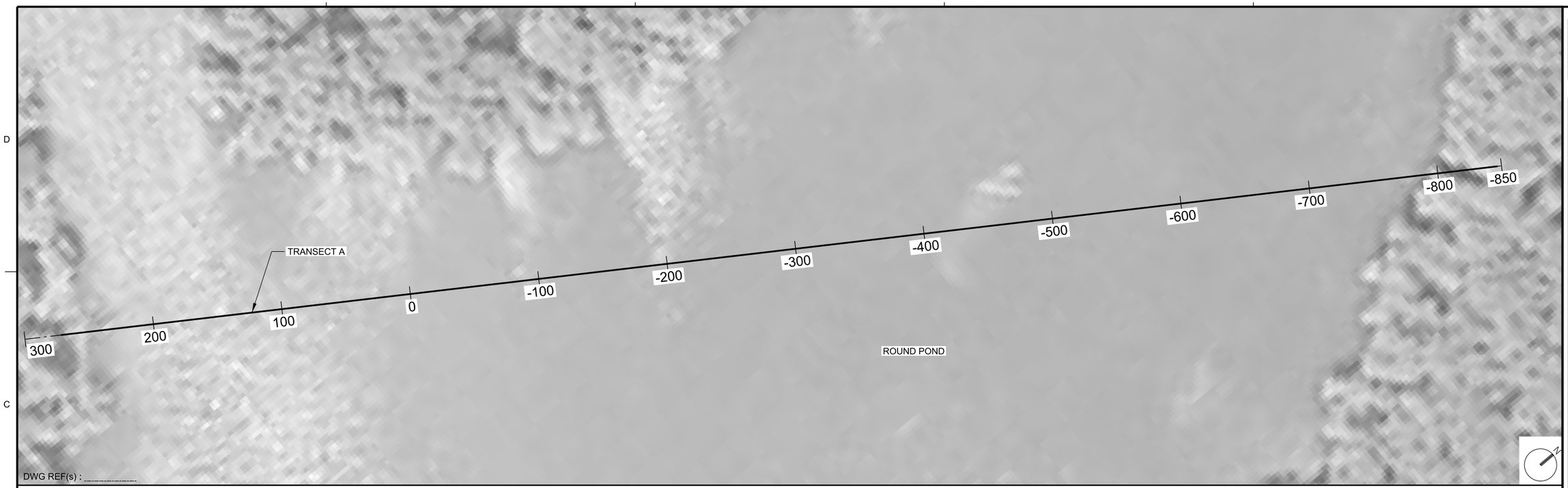
MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

DESIGNED BY: SJG		DATE:	
DWN BY: JMF	CKD BY:	SOLICITATION NO.:	
SUBMITTED BY: HLA		CONTRACT NO.:	
PLOT SCALE: 1 = 1	PLOT DATE:	PROJECT CODE: PER	
FILE NAME: PERC-101xx.dgn			

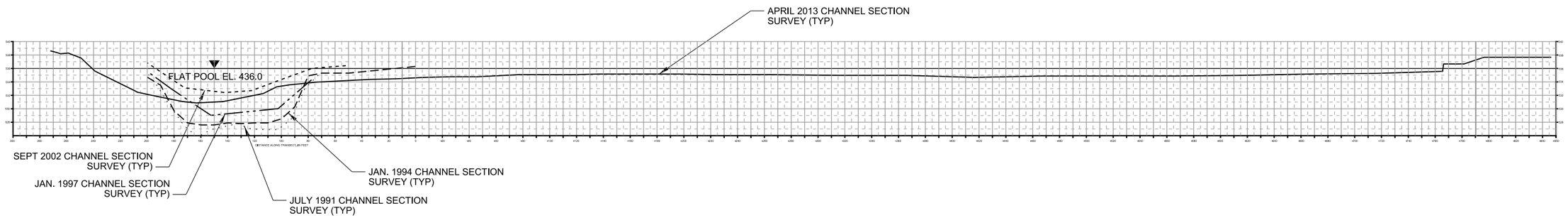
MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
SITE PLAN

Sheet ID
C-101



C1 TRANSECT A PLAN

SCALE : 1"=40'-0" 0 40' 80'



DWG REF(s) : _____

A1 TRANSECT A PROFILE

SCALE : 1"=40'-0" 0 40' 80'

US Army Corps of Engineers®

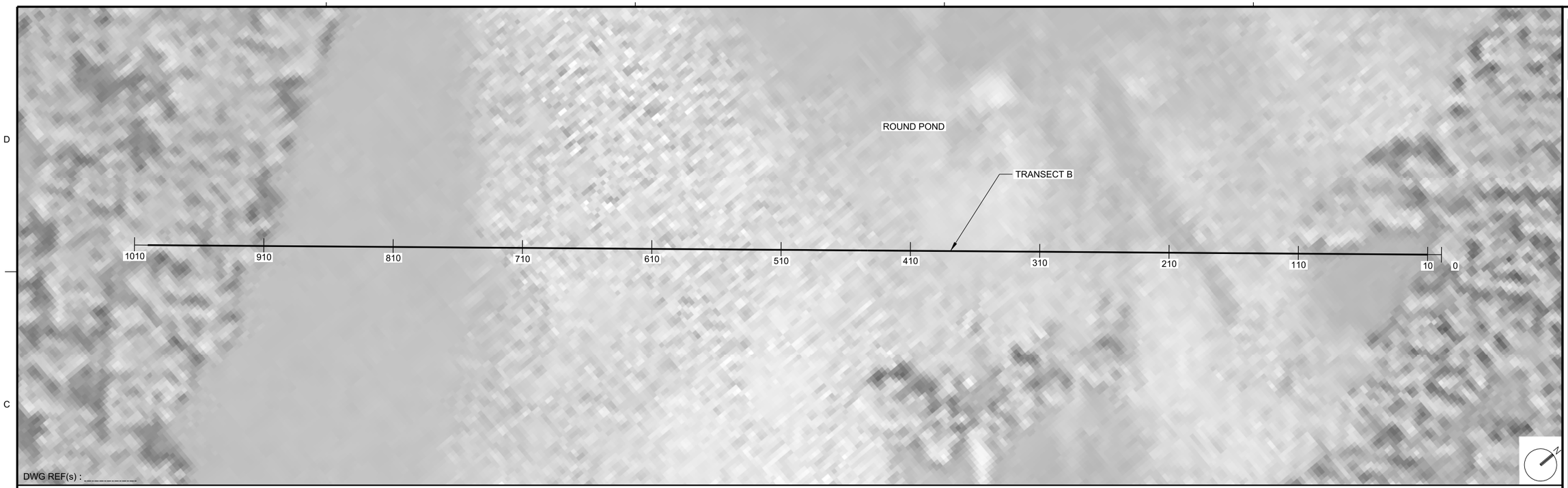
MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

DESIGNED BY: SJG
DWN BY: JMF
CKD BY:
SUBMITTED BY: HLA
PLOT SCALE: AS IS
SIZE: ANSI D
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
PLOT DATE:
FILE NAME: PER-102xxx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
TRANSECT A
PLAN AND PROFILE

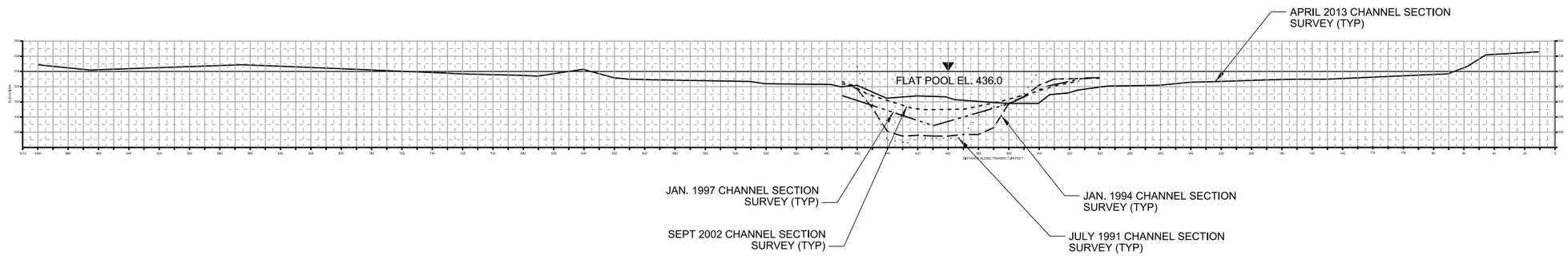
Sheet ID
C-102



DWG REF(s) : _____

C1 TRANSECT B PLAN

SCALE : 1"=40'-0" 0 40' 80'



DWG REF(s) : _____

A1 TRANSECT B PROFILE

SCALE : 1"=40'-0" 0 40' 80'

US Army Corps of Engineers®

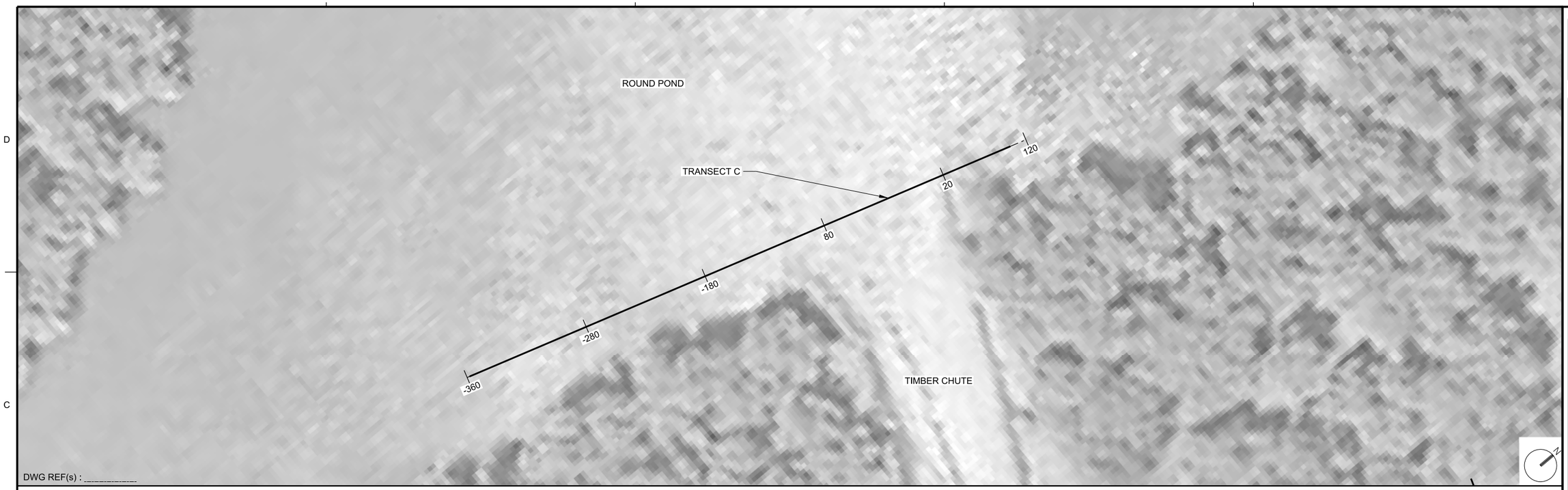
MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: SJG
DRN BY: JMF
SUBMITTED BY: HLA
PLOT SCALE: AS IS
SIZE: ANSI D
DATE:
CKD BY:
SOLICITATION NO.:
CONTRACT NO.:
PLOT DATE:
PROJECT CODE: PER
FILE NAME: PER-103xxx.dgn

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
TRANSECT B
PLAN AND PROFILE

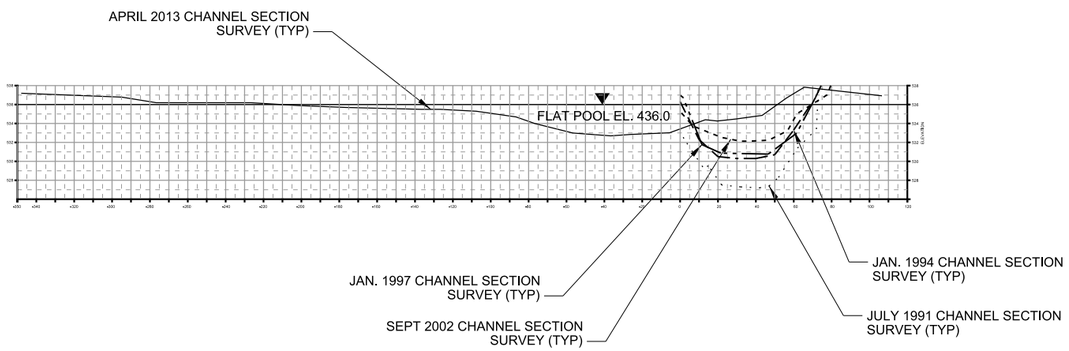
Sheet ID
C-103



DWG REF(s) : _____

C1 TRANSECT C PLAN

SCALE : 1"=40'-0" 0 40' 80'



DWG REF(s) : _____

A1 TRANSECT C PROFILE

SCALE : 1"=40'-0" 0 40' 80'

US Army Corps of Engineers®

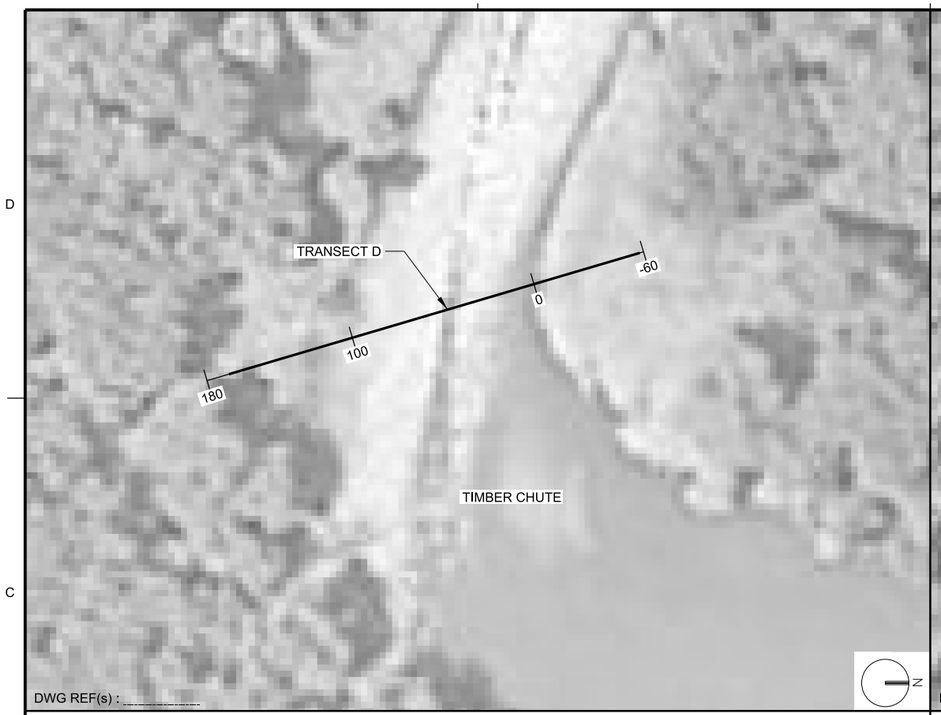
MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

DESIGNED BY: SJG
DWN BY: JMF
SUBMITTED BY: HLA
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
PLOT SCALE: N.T.S.
PLOT DATE:
SIZE: ANSI D
FILE NAME: PER-104xxx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
TRANSECT C
PLAN AND PROFILE

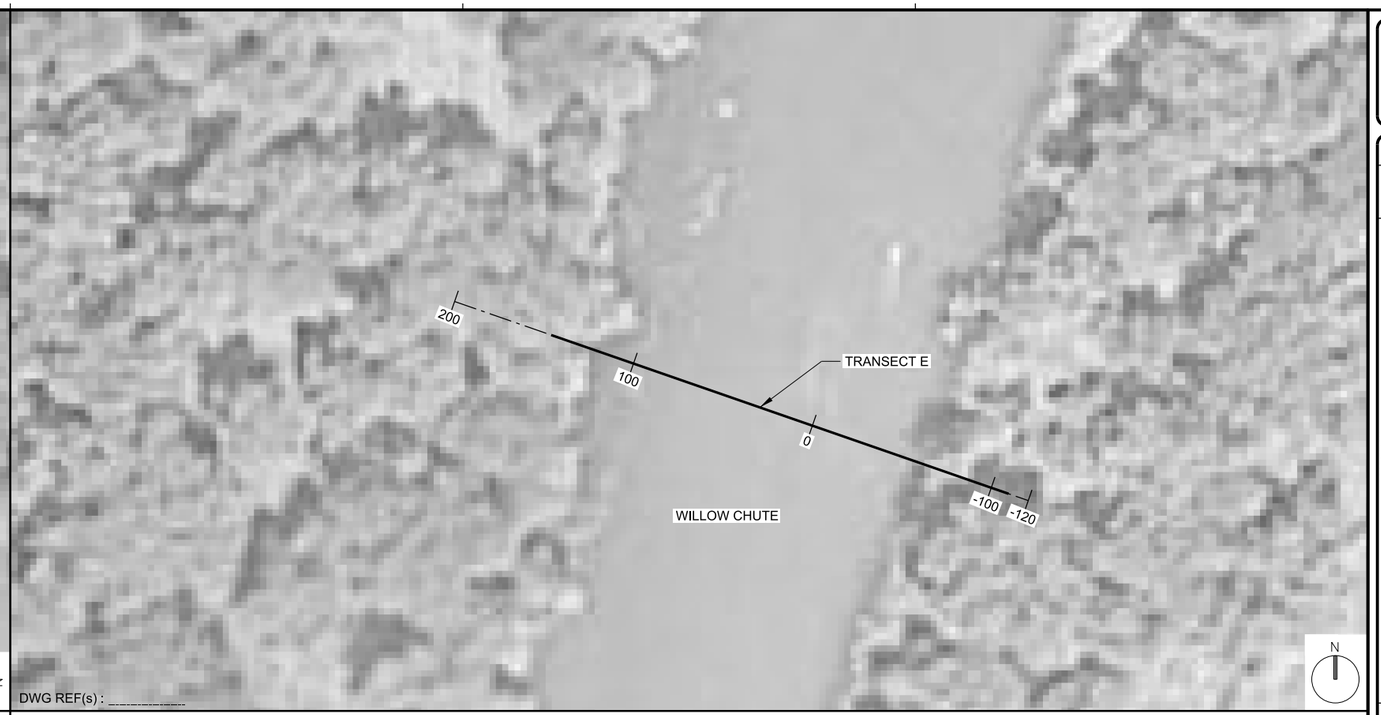
Sheet ID
C-104



DWG REF(s) : _____

C1 TRANSECT D PLAN

SCALE : 1"=40'-0" 0 40' 80'



DWG REF(s) : _____

C3 TRANSECT E PLAN

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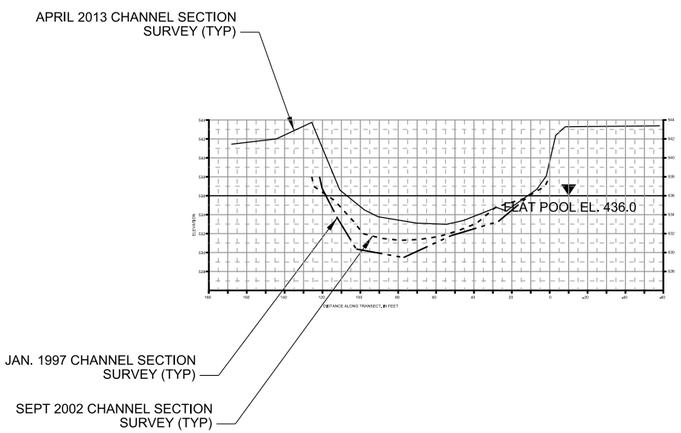
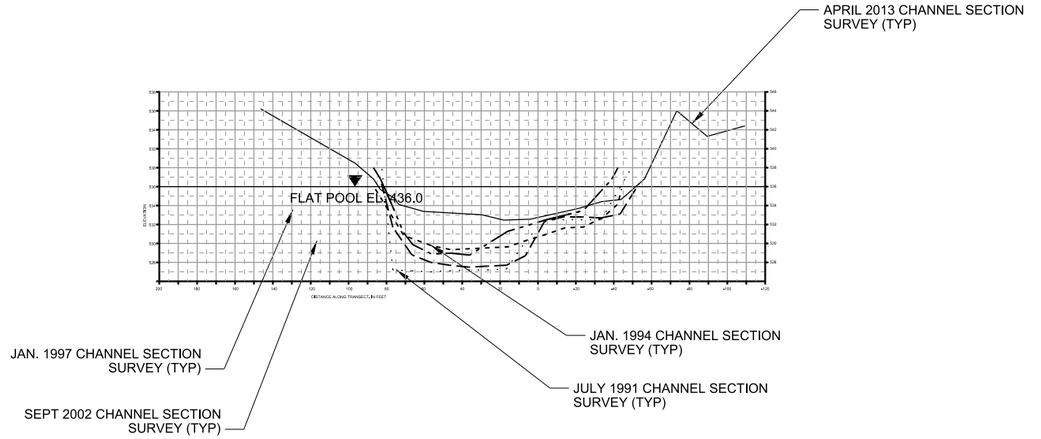


DWG REF(s) : _____

A1 TRANSECT D PROFILE

SCALE : 1"=40'-0" 0 40' 80'



DWG REF(s) : _____

A3 TRANSECT E PROFILE

SCALE : 1"=40'-0" 0 40' 80'

US Army Corps of Engineers®

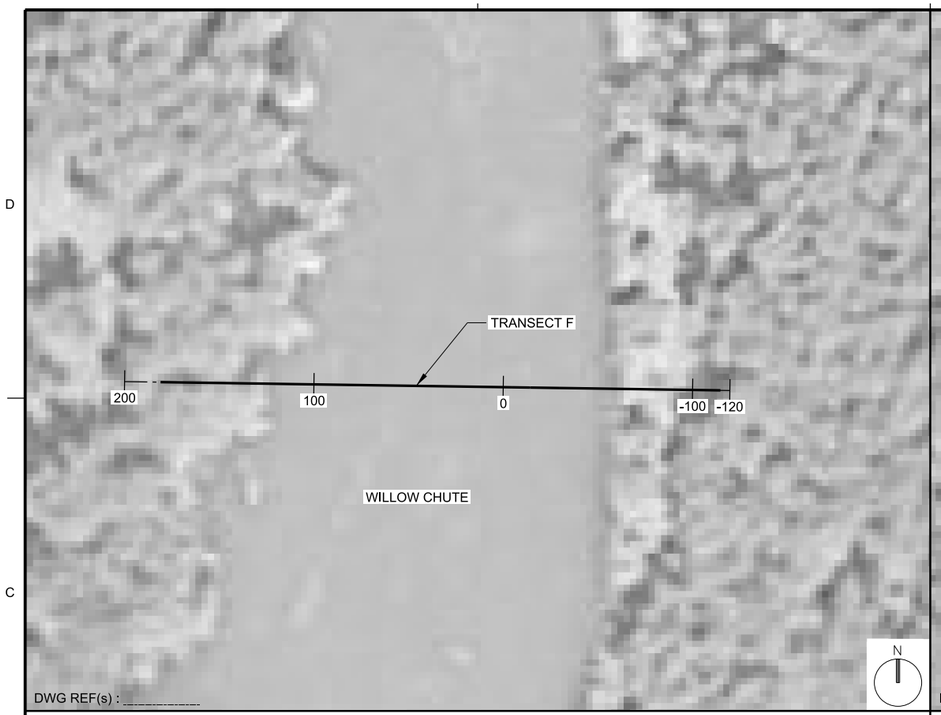
MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

DESIGNED BY: SJG
DWN BY: JMF
CKD BY:
SUBMITTED BY: HLA
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
PLOT SCALE: 1:1
PLOT DATE:
SIZE: ANSI D
FILE NAME: PER-105xxx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
TRANSECT D AND E
PLAN AND PROFILE

Sheet ID
C-105



DWG REF(s) : _____

C1 TRANSECT F PLAN

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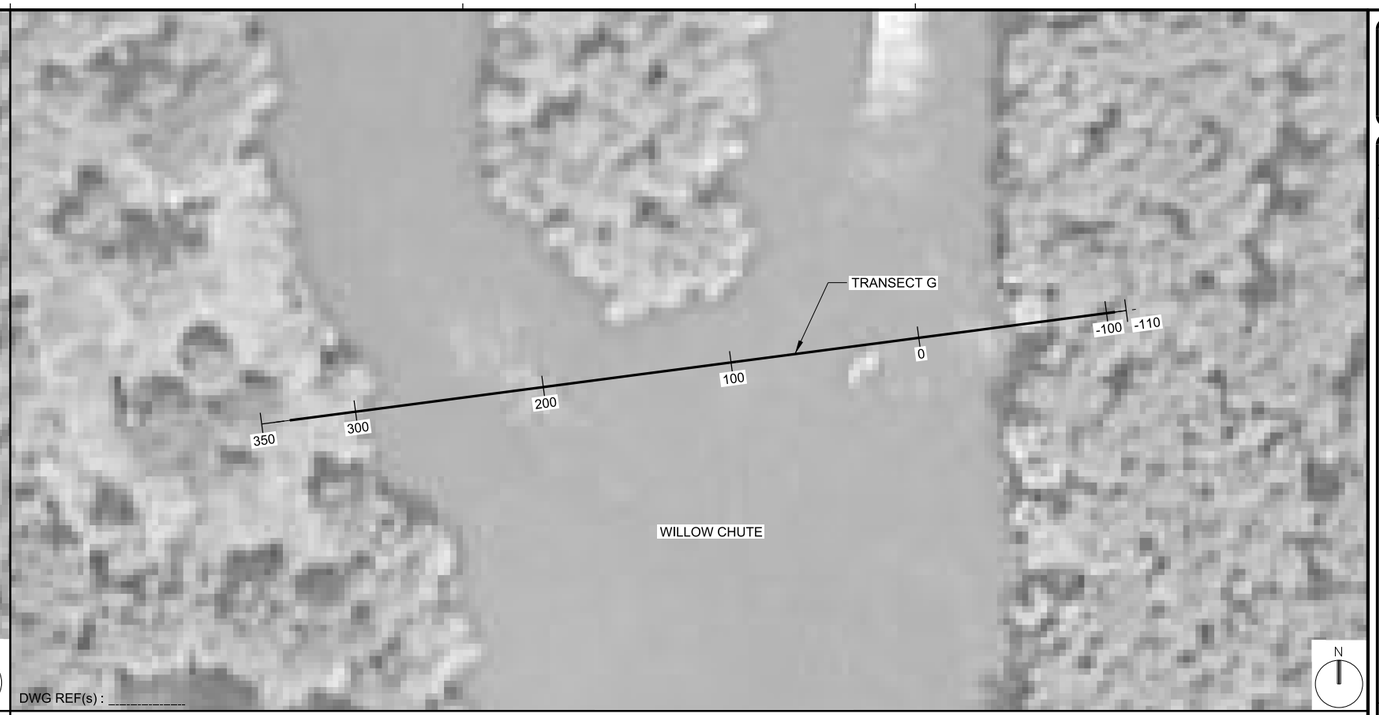
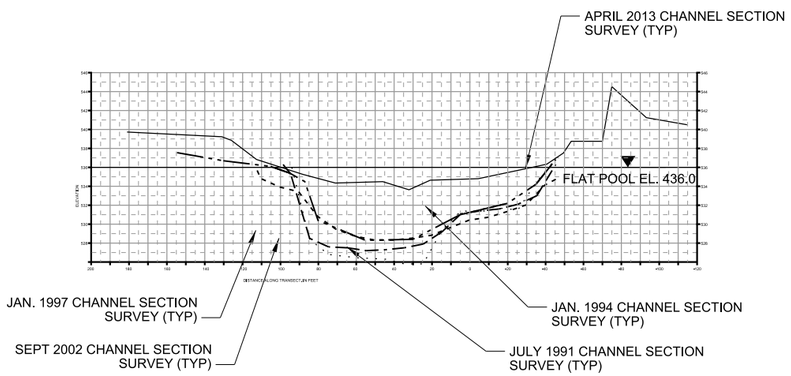


DWG REF(s) : _____

C3 TRANSECT G PLAN

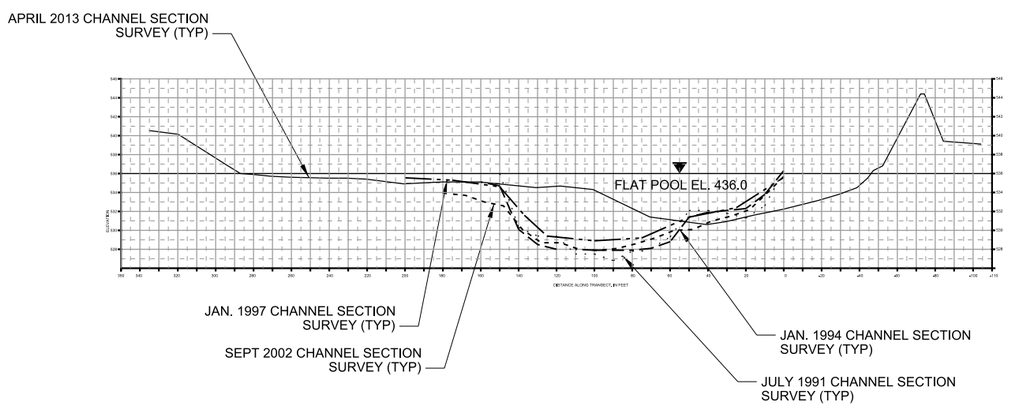
SCALE : 1"=40'-0" 0 40' 80'



DWG REF(s) : _____

A1 TRANSECT F PROFILE

SCALE : 1"=40'-0" 0 40' 80'



DWG REF(s) : _____

A3 TRANSECT G PROFILE

SCALE : 1"=40'-0" 0 40' 80'

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: SJG
DRN BY: JMF
SUBMITTED BY: HLA
PLOT SCALE: AS IS
SIZE: ANSI D
DATE:
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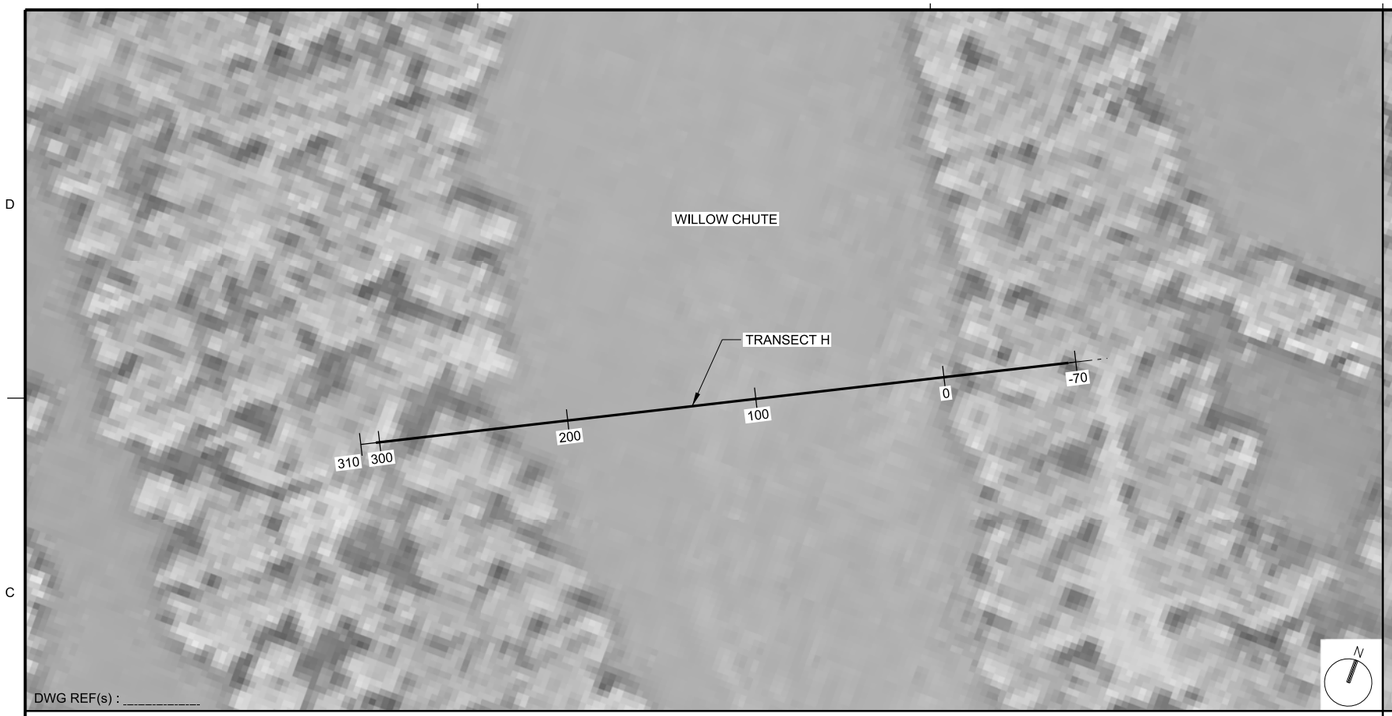
SOLICITATION NO.:
CONTRACT NO.:
PLOT DATE:
PROJECT CODE: PER
FILE NAME: PER-106xxx.dgn

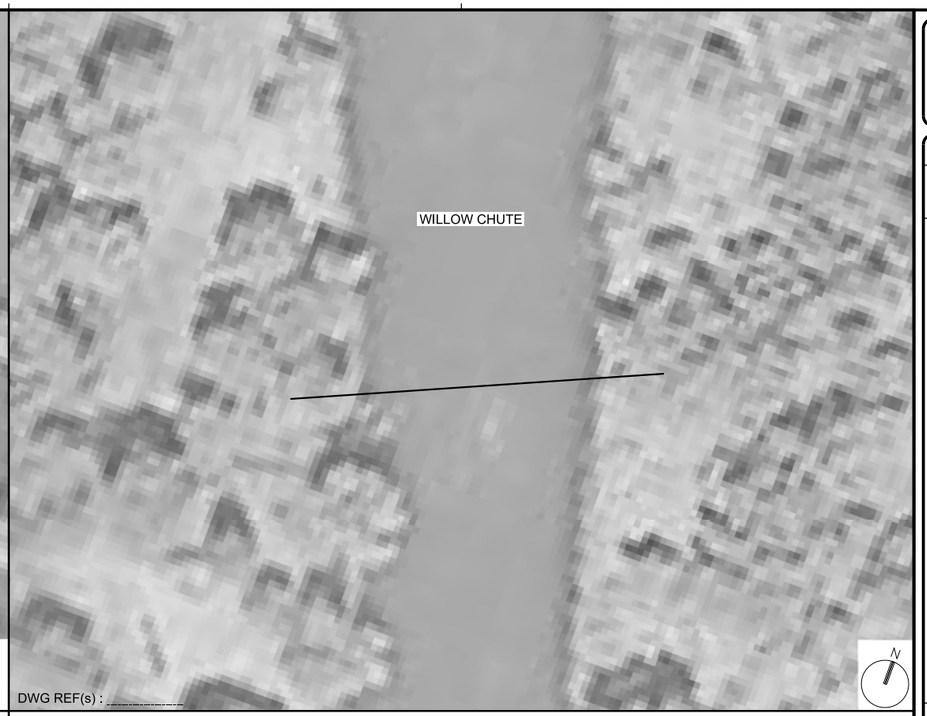
U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
TRANSECT F AND G
PLAN AND PROFILE

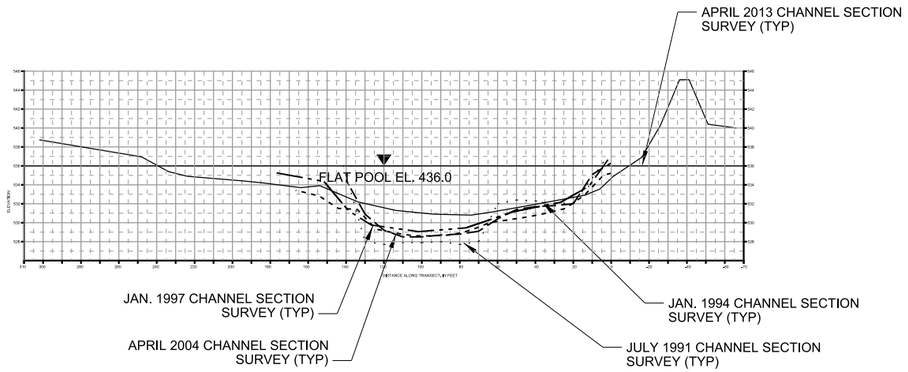
Sheet ID
C-106



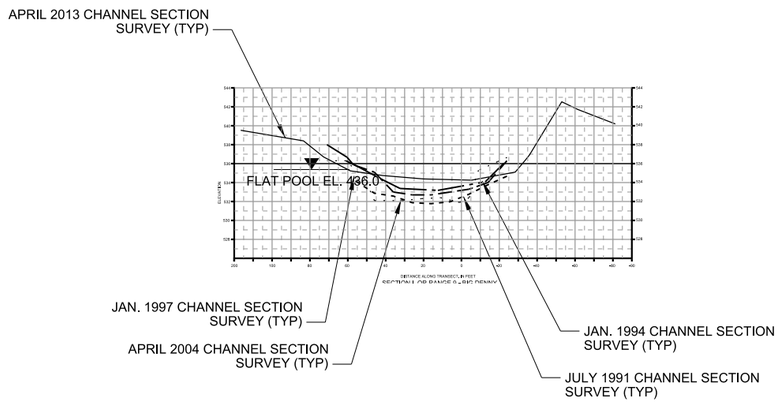
C1 TRANSECT H PLAN
SCALE : 1"=40'-0" 0 40' 80'



C4 TRANSECT L PLAN
SCALE : 1"=40'-0" 0 40' 80'



A1 TRANSECT H PROFILE
SCALE : 1"=40'-0" 0 40' 80'



A4 TRANSECT L PROFILE
SCALE : 1"=40'-0" 0 40' 80'

US Army Corps of Engineers®

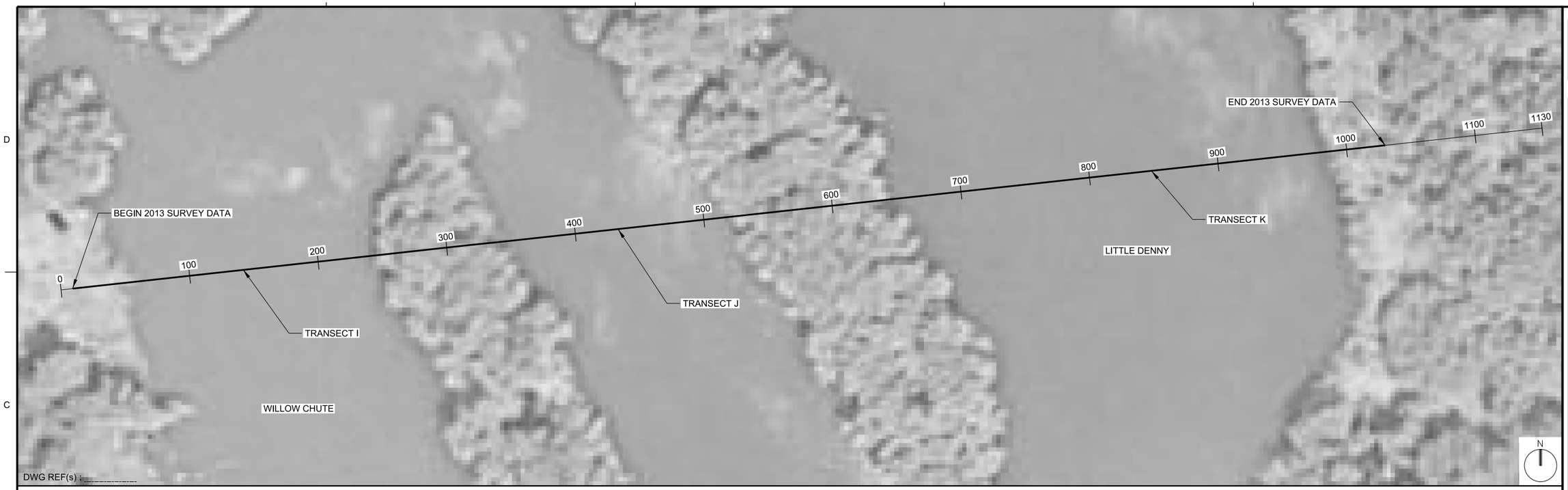
MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: SJG
DWN BY: JMF
SUBMITTED BY: HLA
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
PLOT SCALE: N.T.S.
PLOT DATE:
SIZE: ANSI D
FILE NAME: PER-107xxx.dgn

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
TRANSECT H AND L
PLAN AND PROFILE

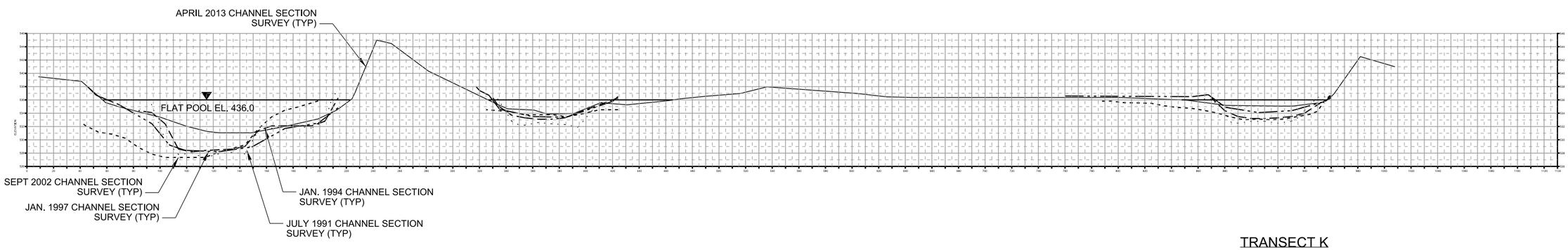
Sheet ID
C-107



DWG REF(s) : _____

C1 TRANSECTS I, J, AND K PLAN

SCALE : 1"=40'-0" 0 40' 80'



DWG REF(s) : _____

A1 TRANSECTS I, J, AND K PROFILE

SCALE : 1"=40'-0" 0 40' 80'

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

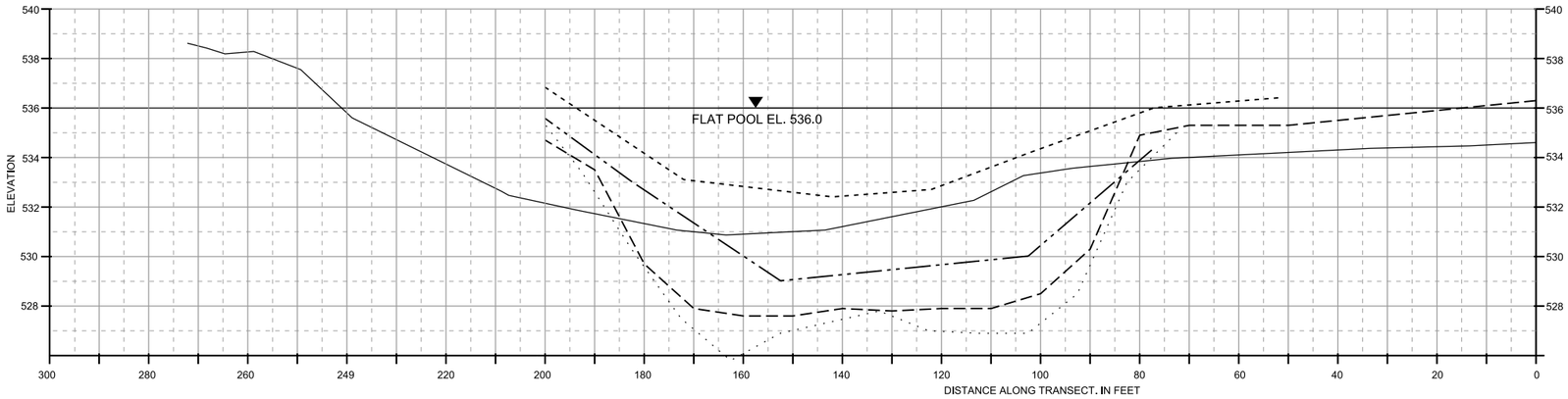
DESIGNED BY: SJG
DWN BY: JMF
SUBMITTED BY: HLA
CKD BY:
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
PLOT SCALE: 1:1
PLOT DATE:
SIZE: ANSI D
FILE NAME: PER-108xxx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
TRANSECTS I, J, AND K
PLAN AND PROFILE

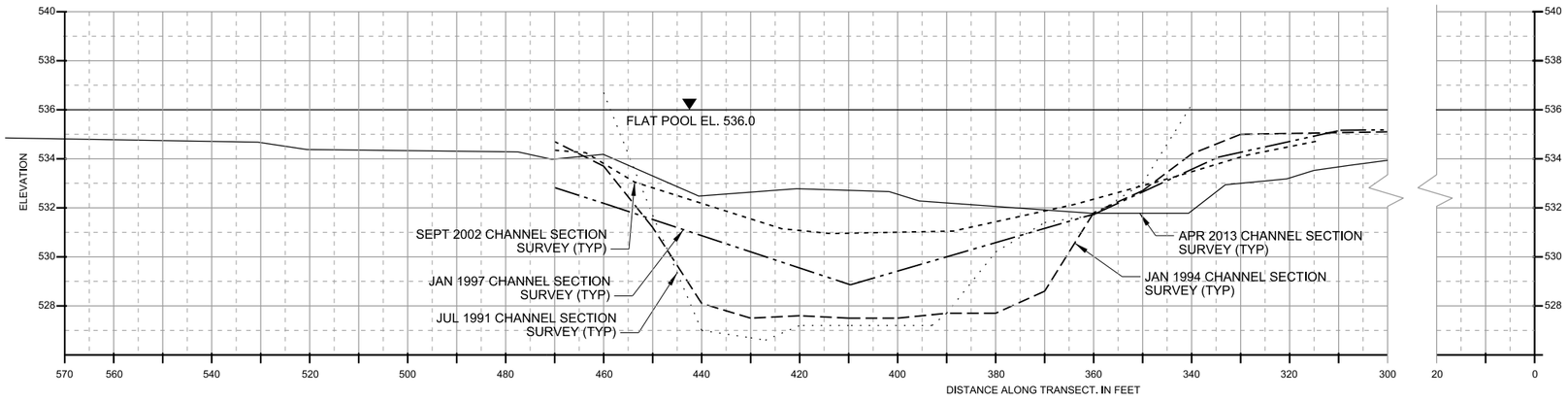
Sheet ID
C-108

SHEET NOTES

1. STATIONING IS BASED OFF OF JANUARY 1994 SURVEY.



SECTION A OR RANGE 1 - ROUND POND



SECTION B OR RANGE 2 - ROUND POND

KEY

- CHANNEL SECTION. AS COMPLETED IN JULY 1991
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1994
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1997
- CHANNEL SECTION. AS SOUNDED IN SEPTEMBER 2002
- CHANNEL SECTION. AS SOUNDED IN APRIL 2013

DWG REF(s) : _____

A1 ROUND POND - TRANSECTS SECTIONS A AND B

SCALE : 1"=15'-0"

0 15' 30'

US Army Corps of Engineers®

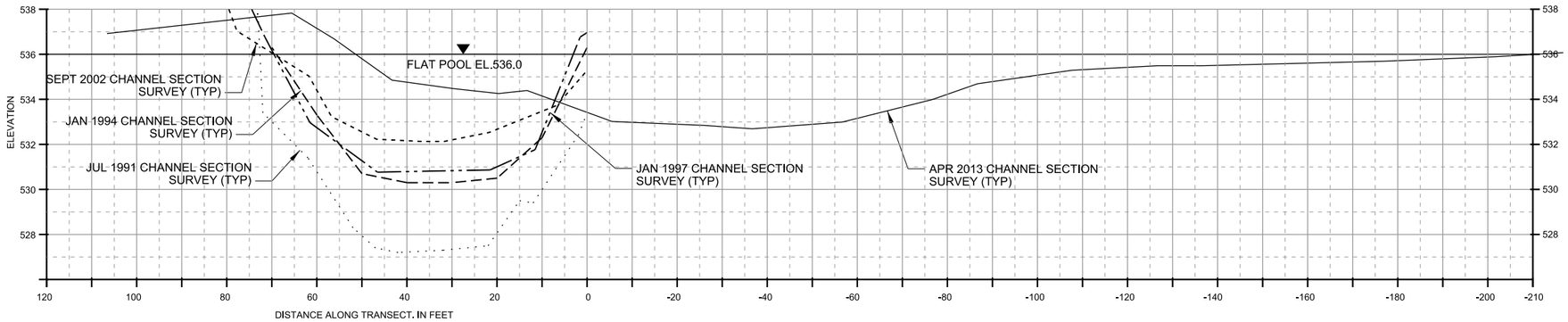
MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

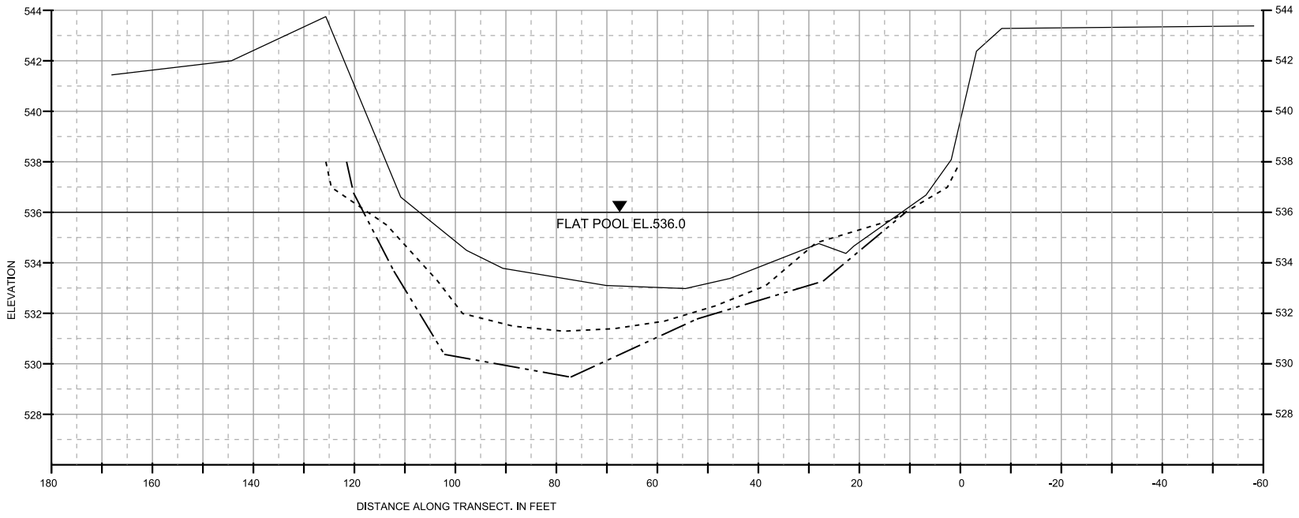
DESIGNED BY: SJG
DWN BY: JMF
CKD BY:
SUBMITTED BY: HLA
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PLOT SCALE: 1" = 1'
PLOT DATE:
PROJECT CODE: PER
FILE NAME: PERC-301xx.dgn
SIZE: ANSI D

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
ROUND POND - TRANSECTS
SECTIONS A AND B

Sheet ID
C-301



SECTION C OR RANGE 3 - TIMBER CHUTE



SECTION D OR RANGE 3A - TIMBER CHUTE

SHEET NOTES

1. STATIONING IS BASED OFF OF JANUARY 1994 SURVEY.

KEY

- CHANNEL SECTION. AS COMPLETED IN JULY 1991
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1994
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1997
- CHANNEL SECTION. AS SOUNDED IN SEPTEMBER 2002
- CHANNEL SECTION. AS SOUNDED IN APRIL 2013

DWG REF(s) : _____

A1 TIMBER CHUTE - TRANSECTS SECTIONS C AND D

SCALE : 1"=15'-0" 0 15' 30'

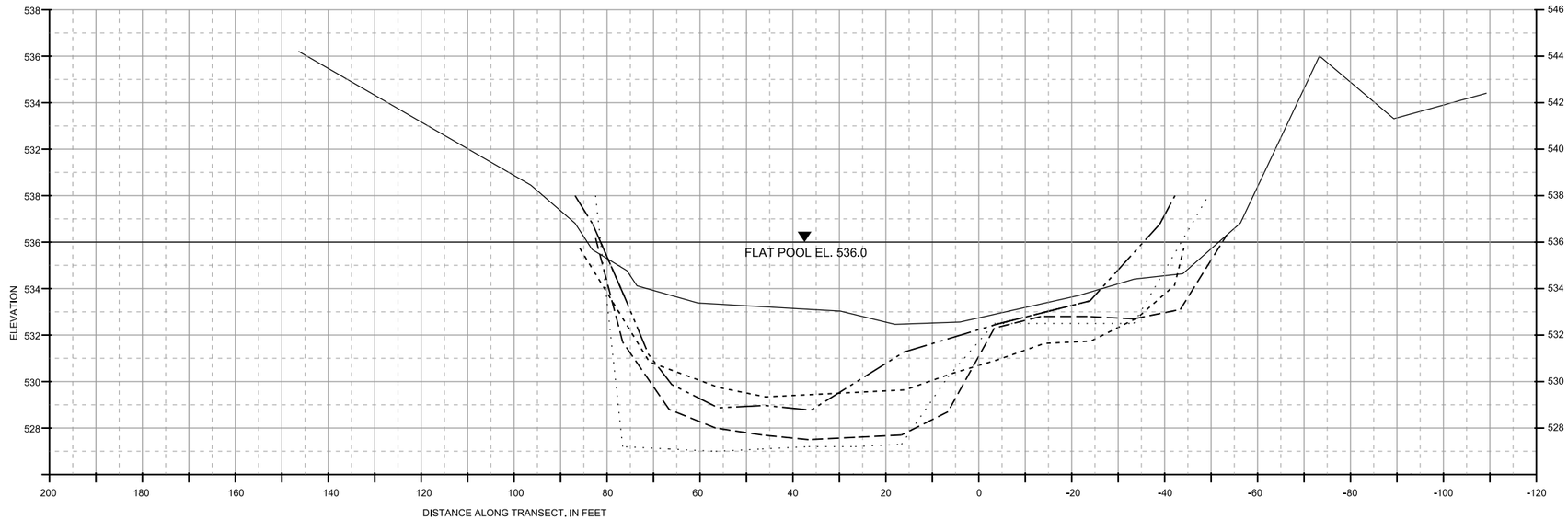
US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

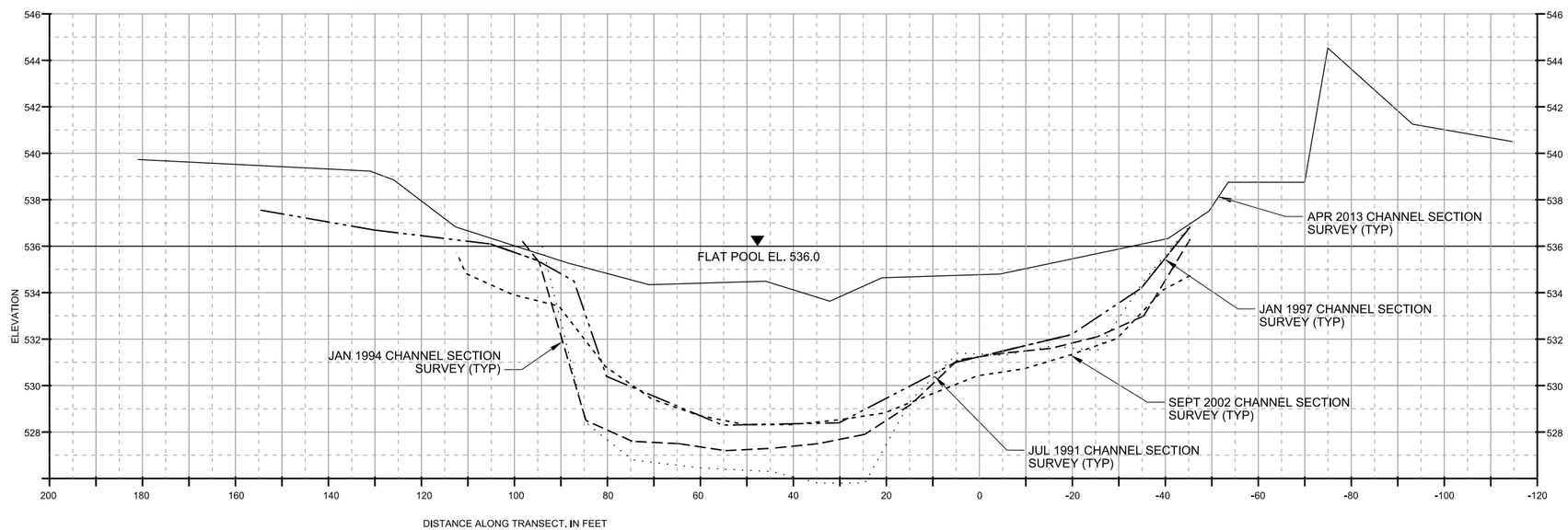
U.S. ARMY CORPS OF ENGINEERS ROCK ISLAND DISTRICT ROCK ISLAND, ILLINOIS	DESIGNED BY: SJG	DATE:	
	DWN BY: JMF	CKD BY:	SOLICITATION NO.:
	SUBMITTED BY: HLA		CONTRACT NO.:
	PLOT SCALE: N.T.S.	PLOT DATE:	PROJECT CODE: PER
	SIZE: ANSI D	FILE NAME: PERC-302xx.dgn	

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
TIMBER CHUTE - TRANSECTS SECTIONS C AND D

Sheet ID C-302



SECTION E OR RANGE 4 - WILLOW CHUTE



SECTION F OR RANGE 5 - WILLOW CHUTE

KEY

- CHANNEL SECTION. AS COMPLETED IN JULY 1991
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1994
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1997
- CHANNEL SECTION. AS SOUNDED IN SEPTEMBER 2002
- CHANNEL SECTION. AS SOUNDED IN APRIL 2013

SHEET NOTES

1. STATIONING IS BASED OFF OF JANUARY 1994 SURVEY.

DWG REF(s) : _____

A1 WILLOW CHUTE - TRANSECTS SECTIONS E AND F

SCALE : 1"=15'-0" 0 15' 30'

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: SJG	DWN BY: JMF	SUBMITTED BY: HLA	PLOT SCALE: NTS
U.S. ARMY CORPS OF ENGINEERS ROCK ISLAND DISTRICT ROCK ISLAND, ILLINOIS			SIZE: ANSI D

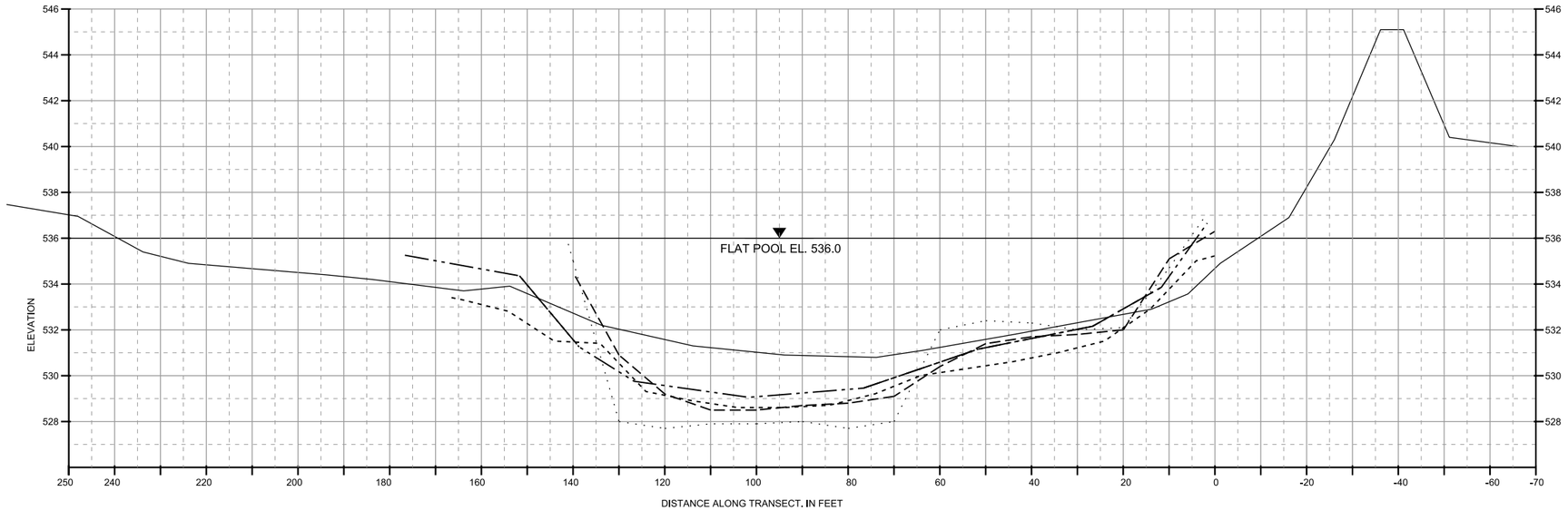
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
PLOT DATE:
FILE NAME: PER-303xxx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
WILLOW CHUTE - TRANSECTS
SECTIONS E AND F

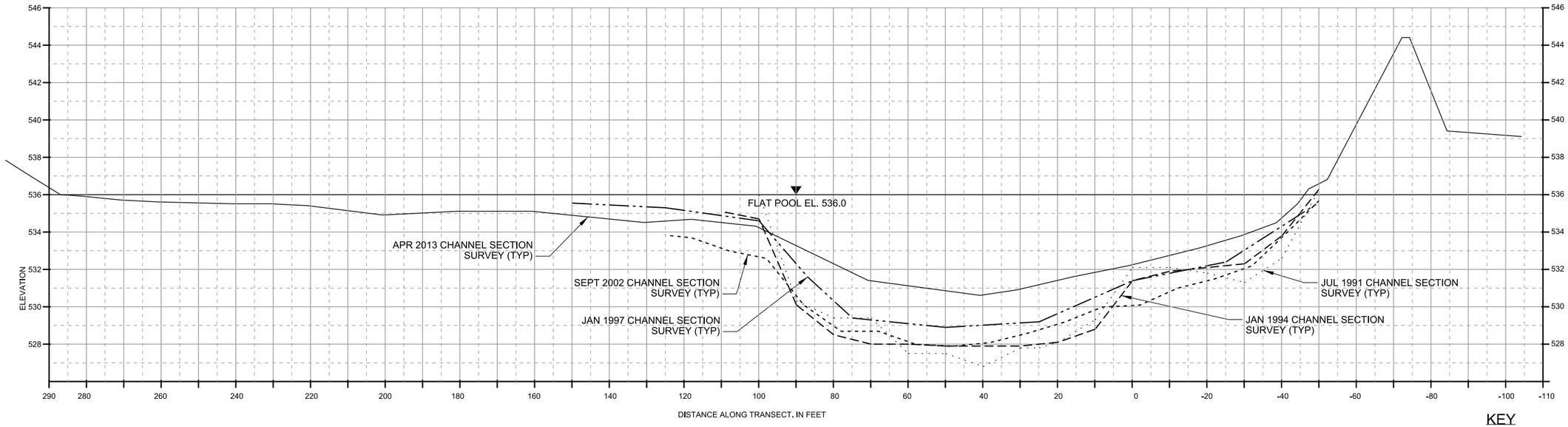
Sheet ID
C-303

SHEET NOTES

1. STATIONING IS BASED OFF OF JANUARY 1994 SURVEY.



SECTION H OR RANGE 7 - WILLOW CHUTE



SECTION G OR RANGE 6 - WILLOW CHUTE

KEY

- CHANNEL SECTION. AS COMPLETED IN JULY 1991
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1994
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1997
- CHANNEL SECTION. AS SOUNDED IN SEPTEMBER 2002
- CHANNEL SECTION. AS SOUNDED IN APRIL 2013

DWG REF(s) : _____

A1 WILLOW CHUTE - TRANSECTS SECTIONS G AND H

SCALE : 1"=15'-0" 0 15' 30'

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

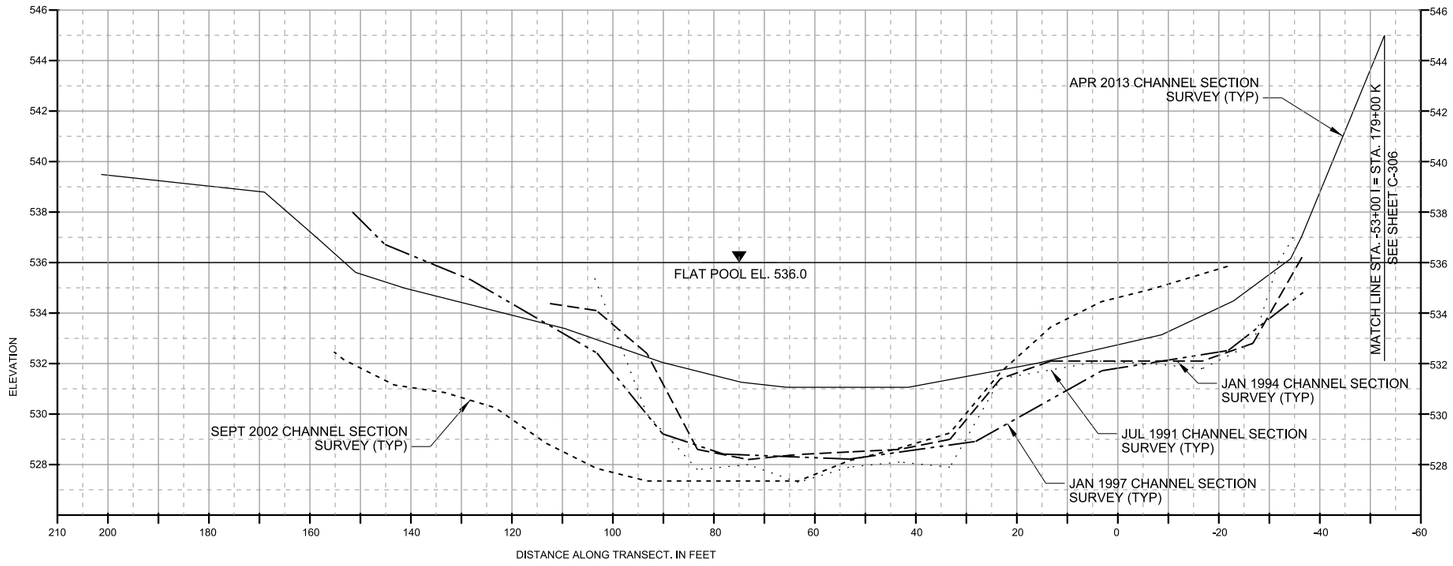
DESIGNED BY: SJG
DWN BY: JMF
CKD BY:
SUBMITTED BY: HLA
PLOT SCALE: 1=1
PLOT DATE:
FILE NAME: PERC-304xx.dgn
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
SIZE: ANSI D

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
WILLOW CHUTE - TRANSECTS
SECTIONS G AND H

Sheet ID
C-304

SHEET NOTES

1. STATIONING IS BASED OFF OF JANUARY 1994 SURVEY.



SECTION I OR RANGE 8 - WILLOW CHUTE

DATA COMPARISON CHART - ELEV. 536.0					
AREA	1991 DATAM	1994 DATAM	1997 DATAM	2002 DATAM	DATAM DIFFERENCE
SECTION I	789 SQ. FT.	786 SQ. FT.	866 SQ. FT.	1,055 SQ. FT.	+ 266 SQ. FT.

DATA COMPARISON CHART - ELEV. 530.0					
AREA	1991 DATAM	1994 DATAM	1997 DATAM	2002 DATAM	DATAM DIFFERENCE
SECTION I	126 SQ. FT.	80 SQ. FT.	99 SQ. FT.	179 SQ. FT.	+ 53 SQ. FT.

KEY

- CHANNEL SECTION. AS COMPLETED IN JULY 1991
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1994
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1997
- CHANNEL SECTION. AS SOUNDED IN SEPTEMBER 2002
- CHANNEL SECTION. AS SOUNDED IN APRIL 2013

DWG REF(s) : _____

A1 WILLOW CHUTE - TRANSECT SECTION I

SCALE : 1"=15'-0" 0 15' 30'

US Army Corps of Engineers®

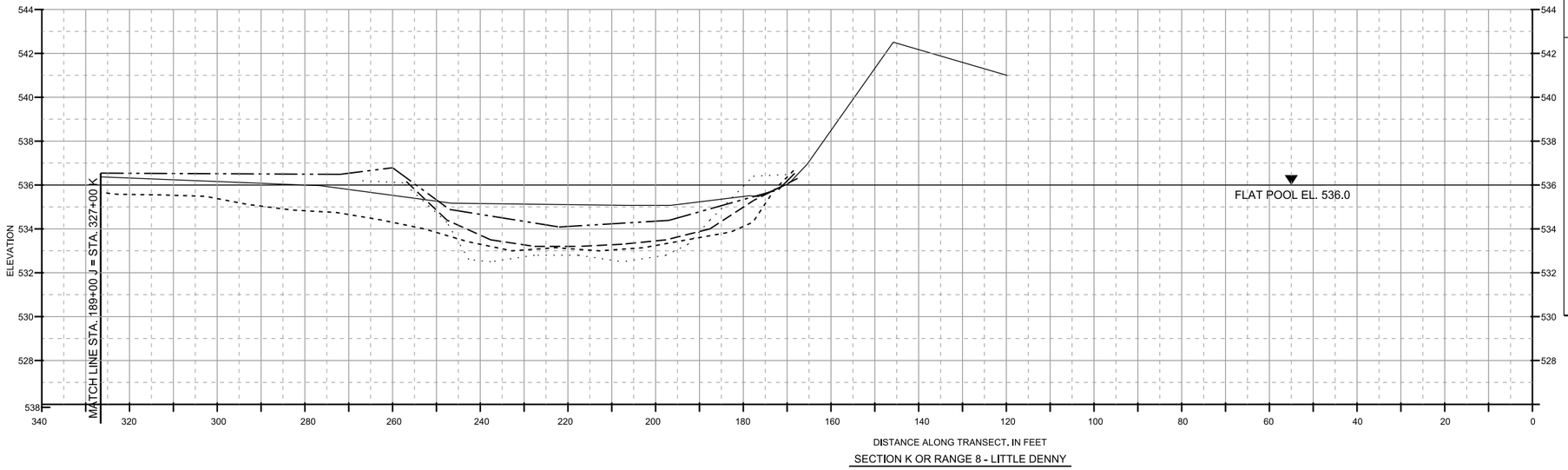
MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

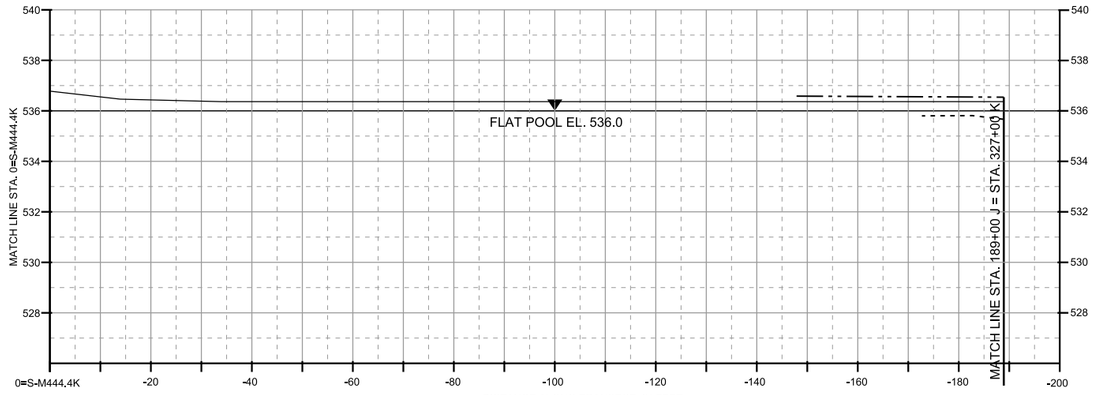
DESIGNED BY: SJG
DWN BY: JMF
SUBMITTED BY: HLA
PLOT SCALE: 1:1
PLOT DATE: AS PER D
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
FILE NAME: PERC-305xx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
WILLOW CHUTE - TRANSECT SECTION I

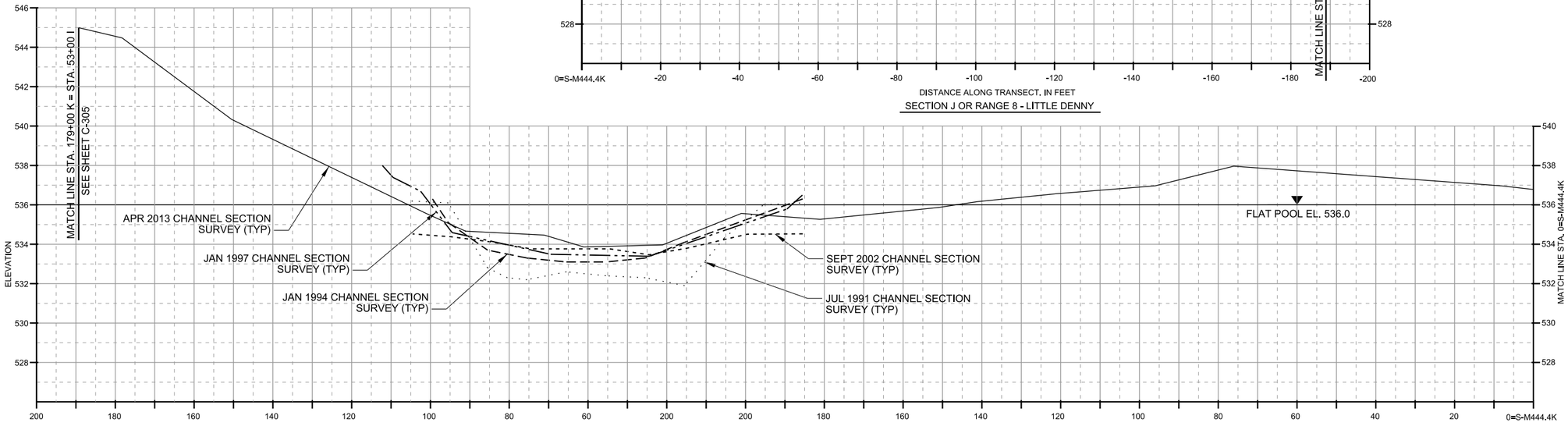
Sheet ID
C-305



SECTION K OR RANGE 8 - LITTLE DENNY



SECTION J OR RANGE 8 - LITTLE DENNY



SECTION J OR RANGE 8 - LITTLE DENNY

DWG REF(s) : _____

SHEET NOTES

1. STATIONING IS BASED OFF OF JANUARY 1994 SURVEY.

KEY

- CHANNEL SECTION. AS COMPLETED IN JULY 1991
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1994
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1997
- CHANNEL SECTION. AS SOUNDED IN SEPTEMBER 2002
- CHANNEL SECTION. AS SOUNDED IN APRIL 2013

A1 LITTLE DENNY - TRANSECTS SECTIONS J AND K

SCALE : 1"=10'-0" 0 10' 20'

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: SJG | DRWN BY: JMF | CKD BY: | SUBMITTED BY: HLA | DATE: | SOLICITATION NO.: | CONTRACT NO.: | PLOT SCALE: N.T.S. | PLOT DATE: | PROJECT CODE: PER | SIZE: ANSI D | FILE NAME: PERC-306xxx.dgn

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

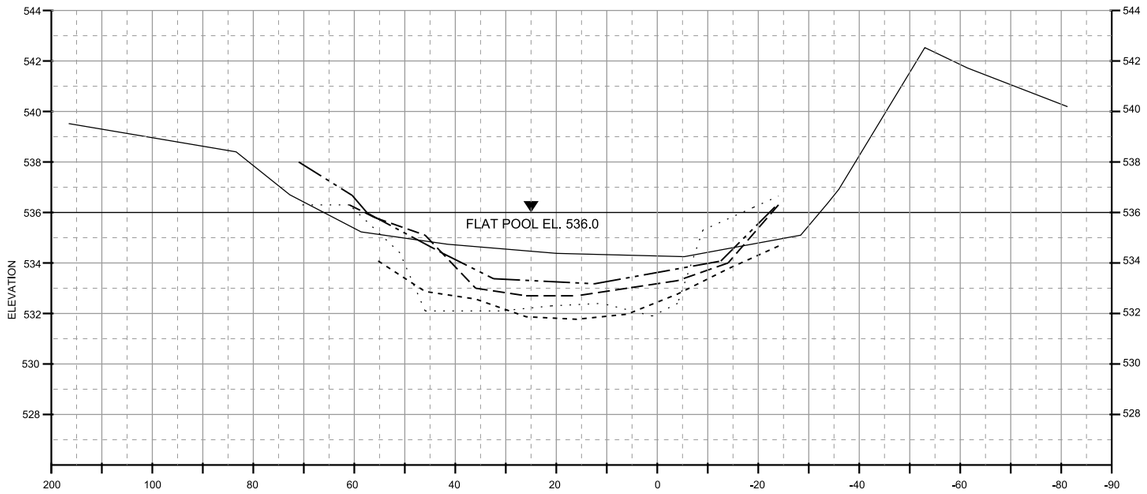
MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT

LITTLE DENNY - TRANSECTS SECTIONS J AND K

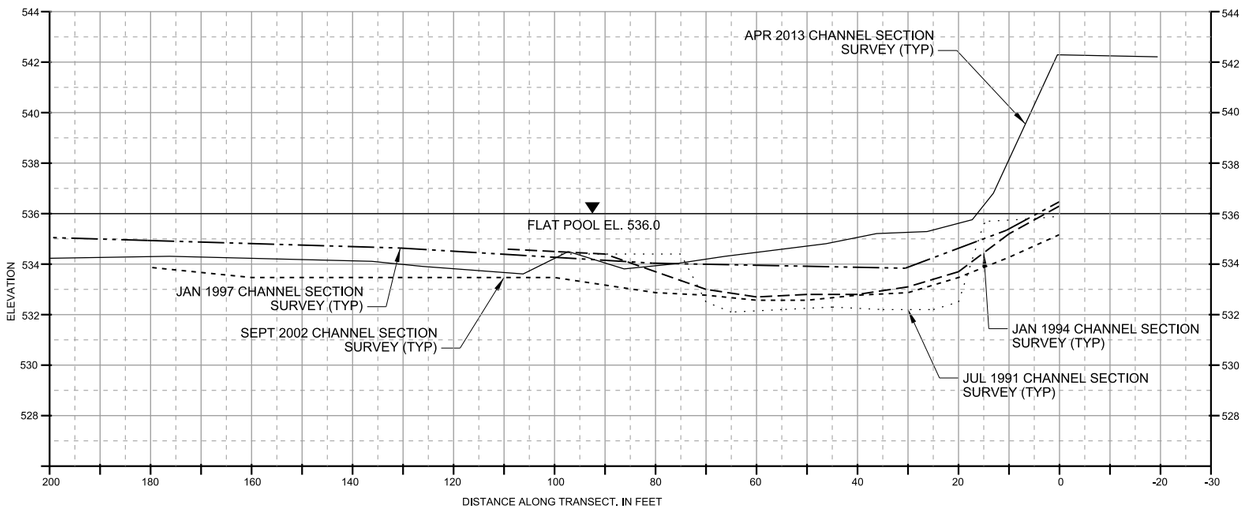
Sheet ID
C-306

SHEET NOTES

1. STATIONING IS BASED OFF OF JANUARY 1994 SURVEY.



SECTION L OR RANGE 9 - BIG DENNY



SECTION M OR RANGE 10 - BIG DENNY

KEY

- CHANNEL SECTION. AS COMPLETED IN JULY 1991
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1994
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1997
- CHANNEL SECTION. AS SOUNDED IN SEPTEMBER 2002
- CHANNEL SECTION. AS SOUNDED IN APRIL 2013

DWG REF(s) : _____

A1 BIG DENNY - TRANSECTS SECTIONS L AND M

SCALE : 1"=15'-0" 0 15' 30'

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

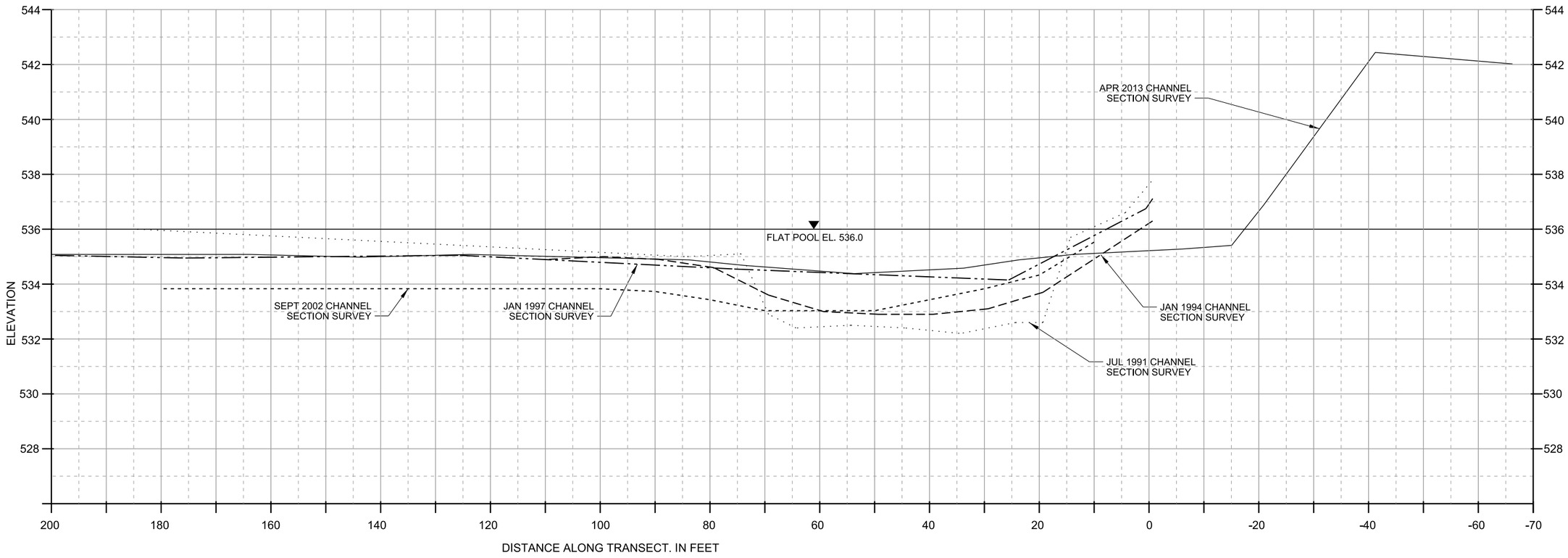
DESIGNED BY: SJG
DWN BY: JMF
SUBMITTED BY: HLA
DATE:
SOLICITATION NO.:
CKD BY:
CONTRACT NO.:
PLOT SCALE: 1=1
PLOT DATE:
PROJECT CODE: PER
SIZE: ANSI D
FILE NAME: PERC-307xx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
BIG DENNY - TRANSECTS
SECTIONS L AND M

Sheet ID
C-307

SHEET NOTES

1. STATIONING IS BASED OFF OF JANUARY 1994 SURVEY.



SECTION N OR RANGE 11 - BIG DENNY

KEY

- CHANNEL SECTION. AS COMPLETED IN JULY 1991
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1994
- CHANNEL SECTION. AS SOUNDED IN JANUARY 1997
- CHANNEL SECTION. AS SOUNDED IN SEPTEMBER 2002
- CHANNEL SECTION. AS SOUNDED IN APRIL 2013

DWG REF(s) : _____

A1 BIG DENNY - TRANSECT SECTION N

SCALE : 1"=15'-0" 0 15' 30'

US Army Corps of Engineers®

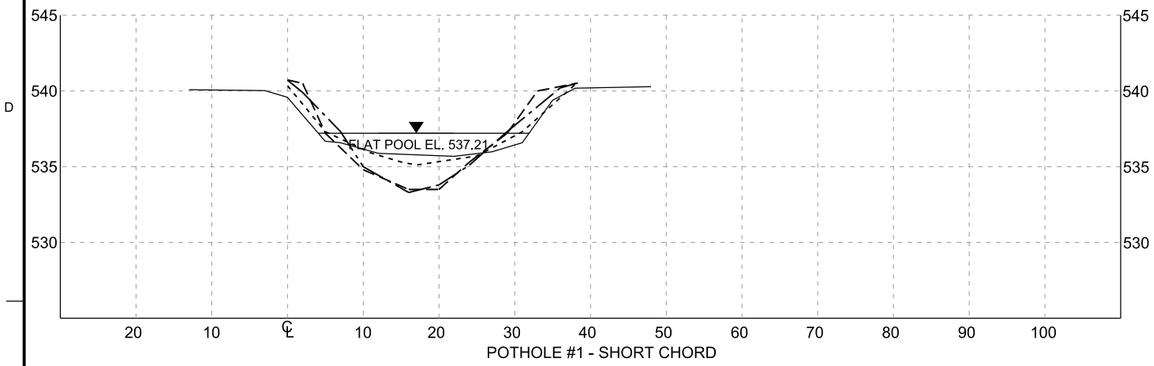
MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

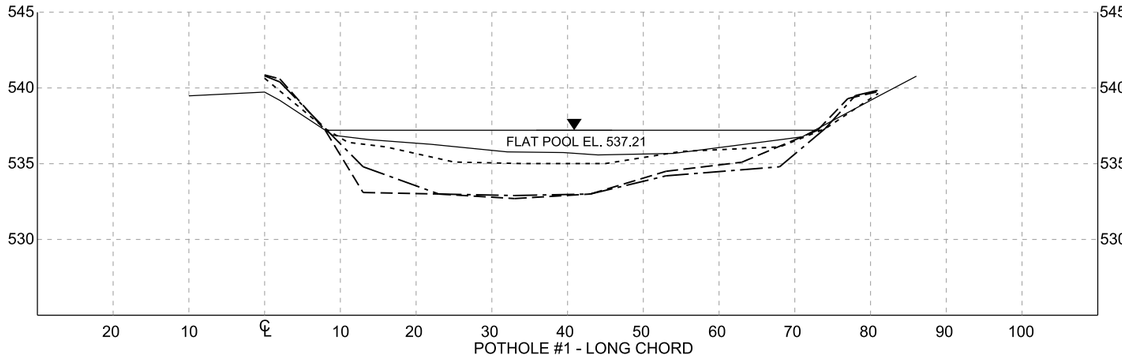
DESIGNED BY: SJG
DWN BY: JMF
CKD BY:
SUBMITTED BY: HLA
PLOT SCALE: 1=1.5
SIZE: ANSI D
DATE:
PLOT DATE:
FILE NAME: PERC-308xxx.dgn
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
BIG DENNY - TRANSECT
SECTION N

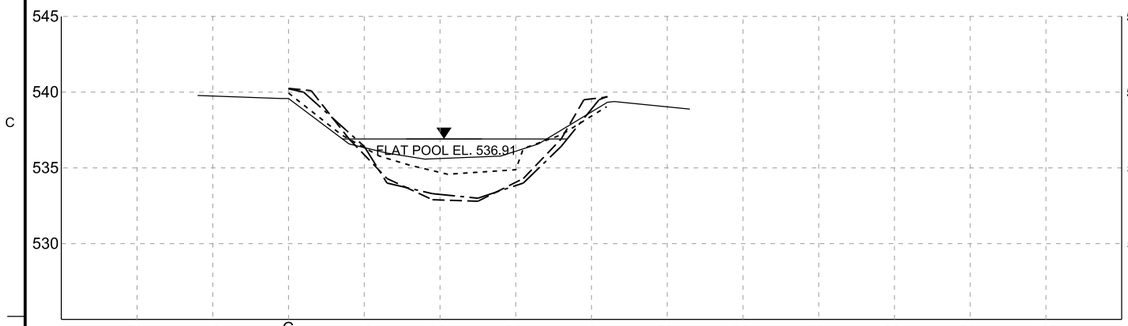
Sheet ID
C-308



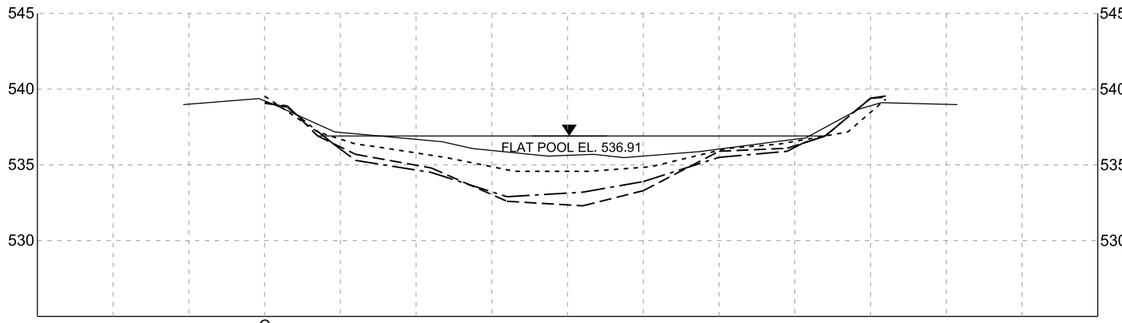
POTHOLE #1 - SHORT CHORD



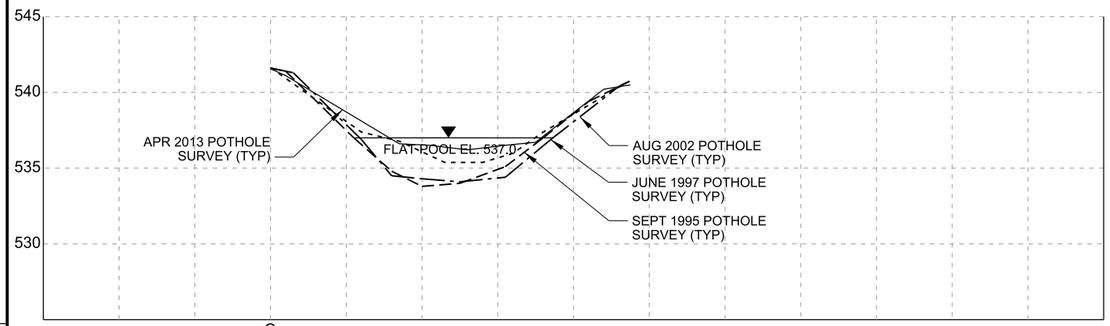
POTHOLE #1 - LONG CHORD



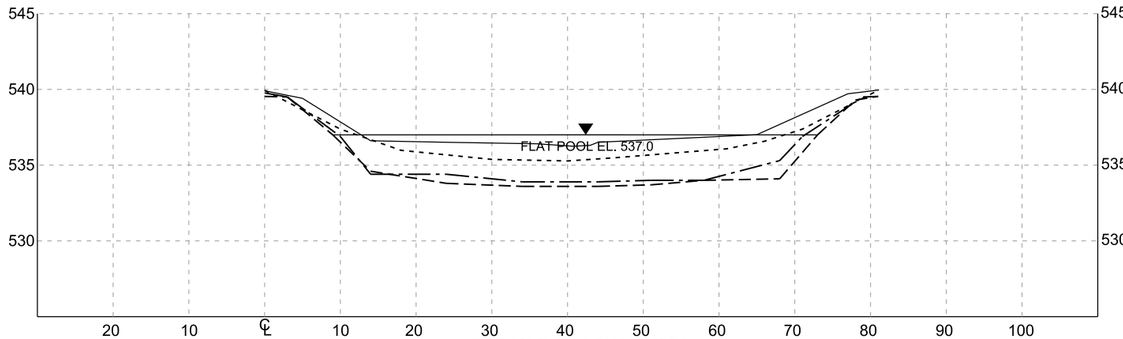
POTHOLE #2 - SHORT CHORD



POTHOLE #2 - LONG CHORD



POTHOLE #3 - SHORT CHORD



POTHOLE #3 - LONG CHORD

DWG REF(s) : _____

A1 SEDIMENTATION TRANSECTS POTHOLES 1-3

SCALE : 1"=10'-0" 0 10' 20'

US Army Corps of Engineers®

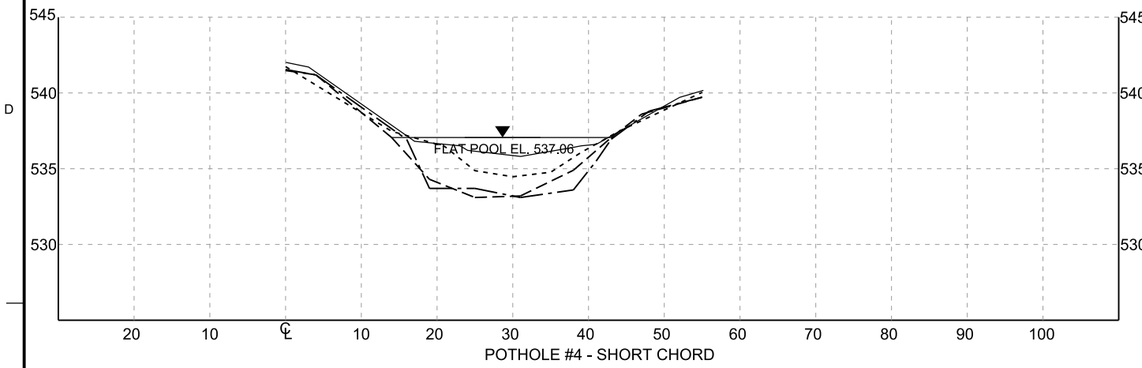
MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

DESIGNED BY: SJG
DWN BY: JMF
SUBMITTED BY: HLA
CKD BY:
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
PLOT SCALE: N.T.S.
SIZE: ANSI D
PLOT DATE:
FILE NAME: PERC-309xxx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
SEDIMENTATION TRANSECTS
POTHOLES 1-3

Sheet ID
C-309



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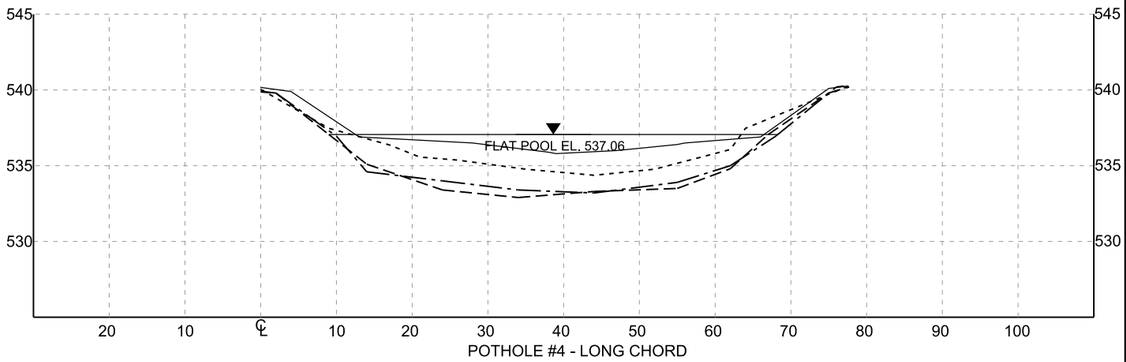

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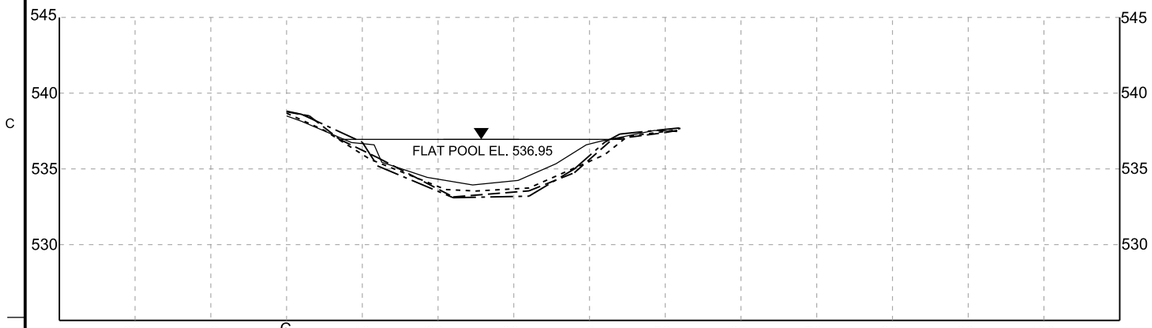

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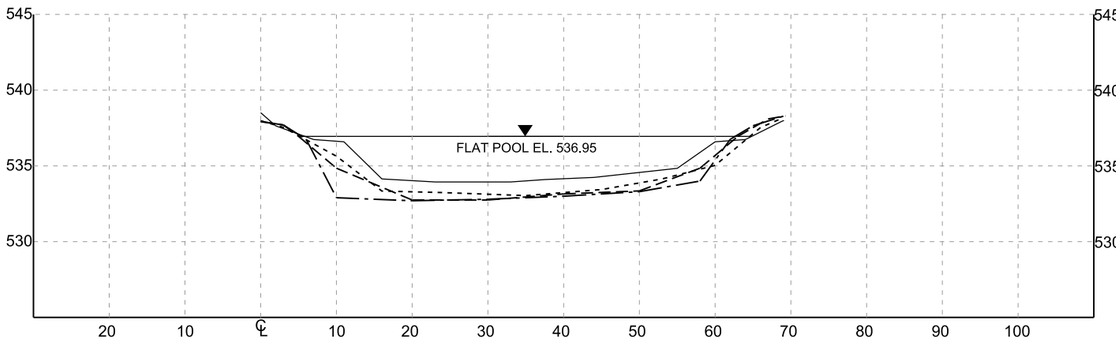
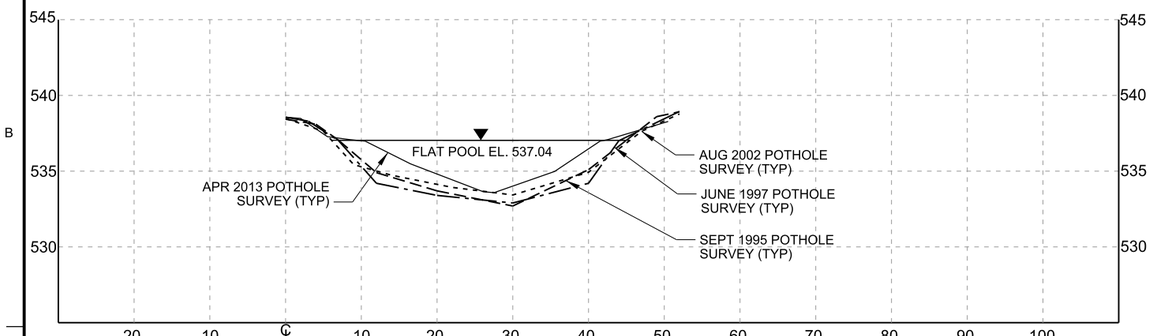


POTHOLE #5 - LONG CHORD



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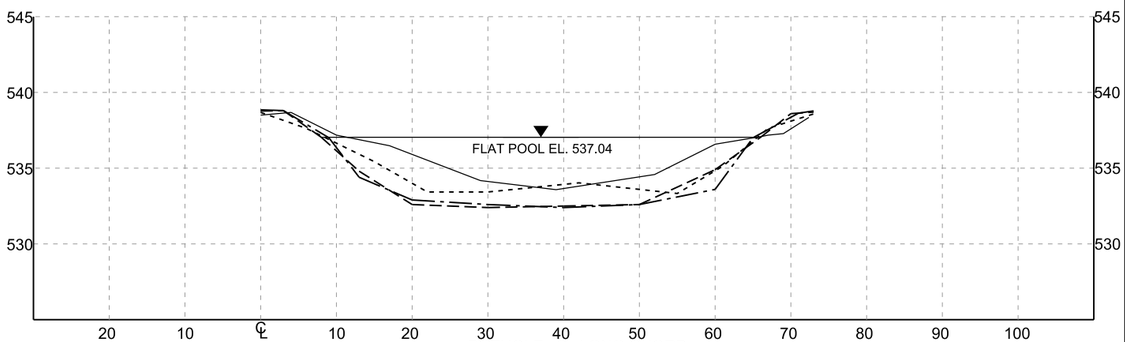


POTHOLE #6 - LONG CHORD

DWG REF(s) : _____

A1 SEDIMENTATION TRANSECTS POTHOLES 4-6

SCALE : 1"=10'-0"

0 10' 20'

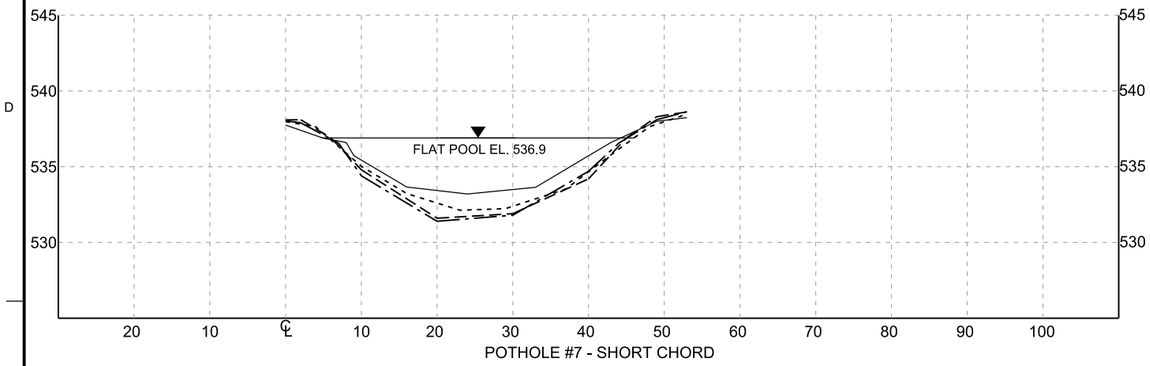
US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS ROCK ISLAND DISTRICT ROCK ISLAND, ILLINOIS	DESIGNED BY: SJG	CKD BY:	DATE:
	DWN BY: JMF	SUBMITTED BY: HLA	SOLICITATION NO.:
	PLOT SCALE: N.T.S.	PLOT DATE:	CONTRACT NO.:
	SIZE: ANSI D	FILE NAME: PERC-310xx.dgn	PROJECT CODE: PER

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
SEDIMENTATION TRANSECTS
POTHOLES 4-6

Sheet ID
C-310



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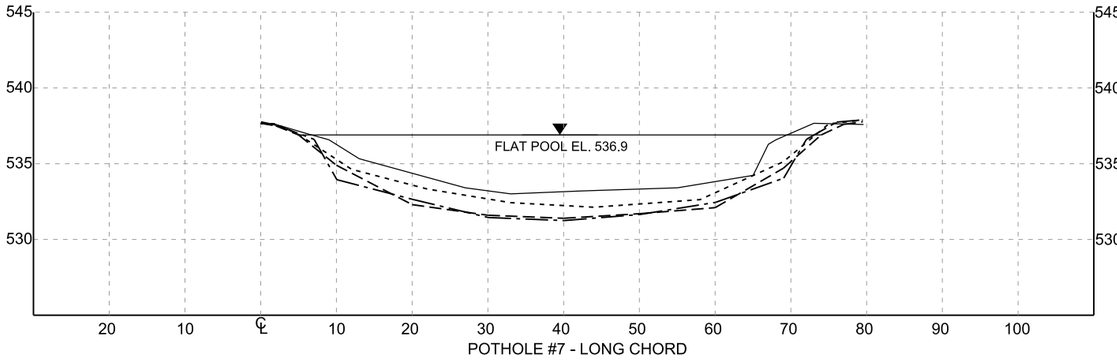

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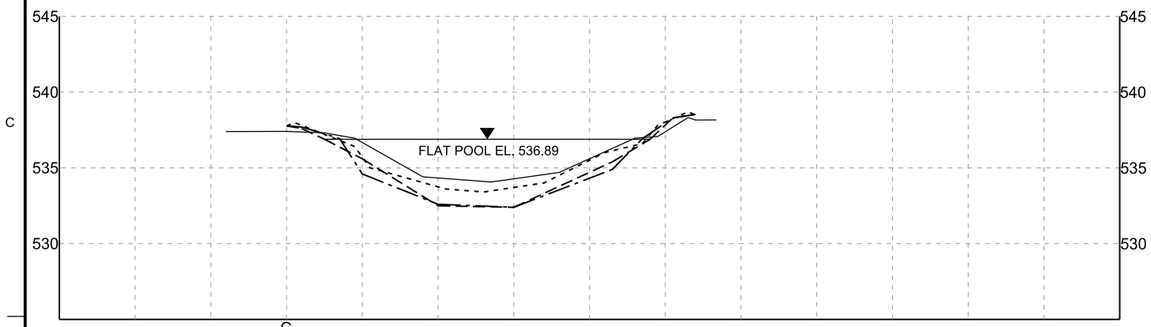
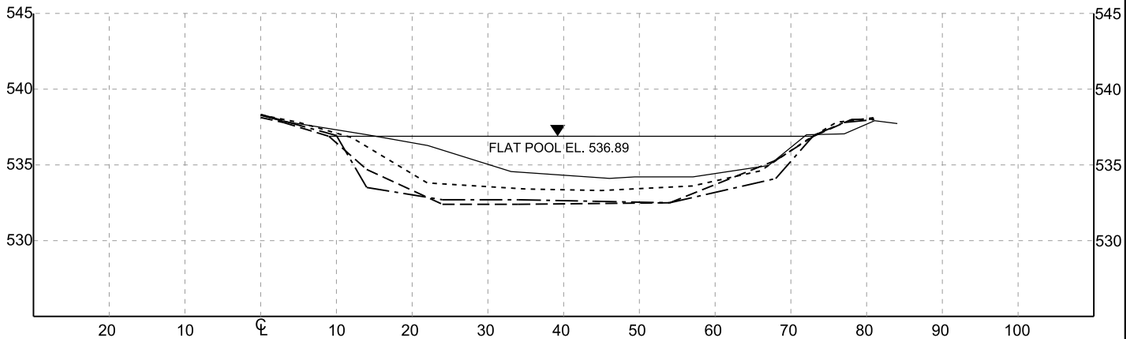
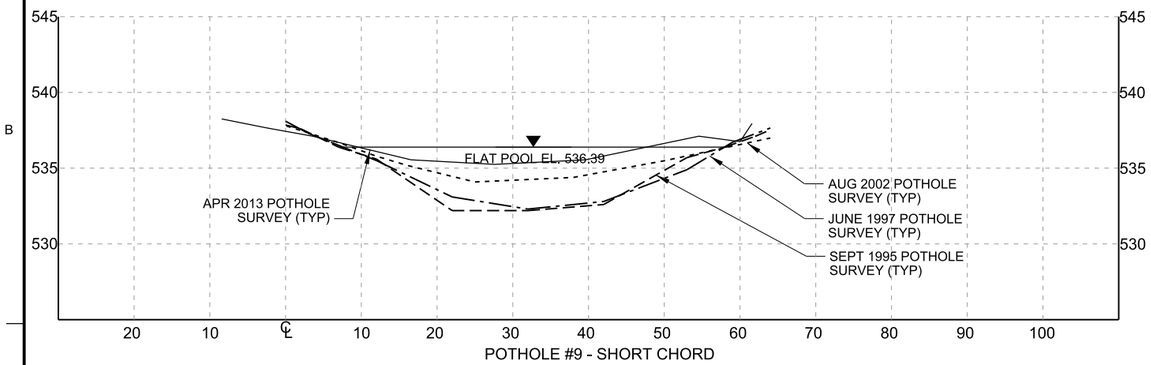


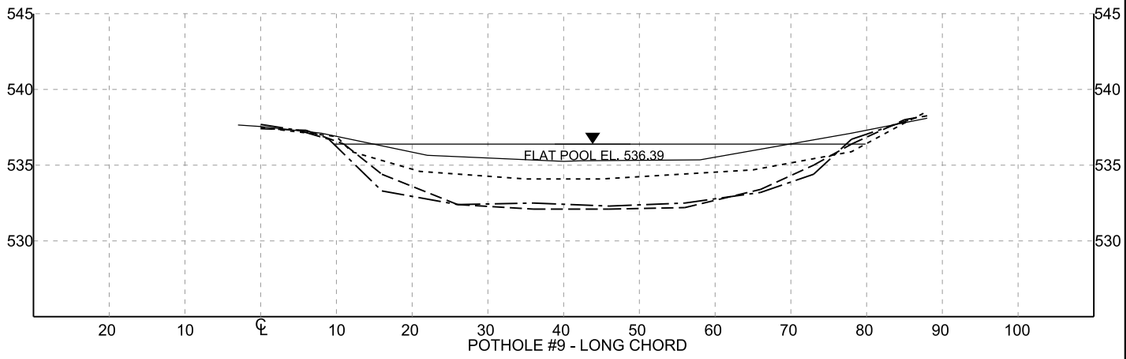
POTHOLE #8 - SHORT CHORD



POTHOLE #8 - LONG CHORD



POTHOLE #9 - SHORT CHORD



POTHOLE #9 - LONG CHORD

DWG REF(s) : _____

A1 SEDIMENTATION TRANSECTS POTHOLES 7-9

SCALE : 1"=10'-0"

0 10' 20'

US Army Corps of Engineers®

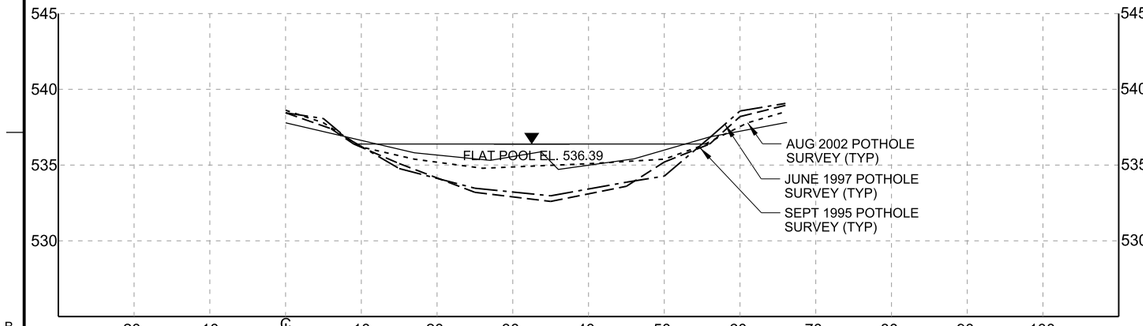
MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

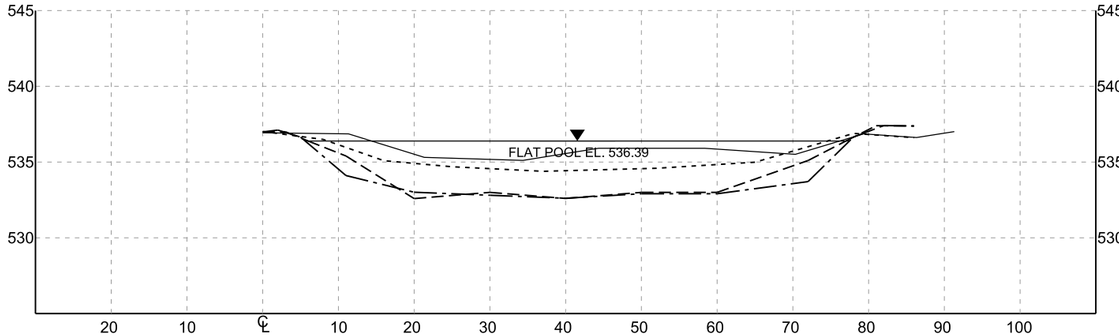
DESIGNED BY: SJG
DWN BY: JMF
CKD BY:
SUBMITTED BY: HLA
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
PLOT SCALE: N.T.S.
PLOT DATE:
SIZE: ANSI D
FILE NAME: PERC-311xxx.dgn

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
SEDIMENTATION TRANSECTS
POTHOLES 7-9

Sheet ID
C-311



POTHOLE #10 - SHORT CHORD



POTHOLE #10 - LONG CHORD

DWG REF(s) : _____

A1 SEDIMENTATION TRANSECT POTHOLE 10

SCALE : 1"=10'-0"

0 10' 20'

US Army Corps of Engineers®

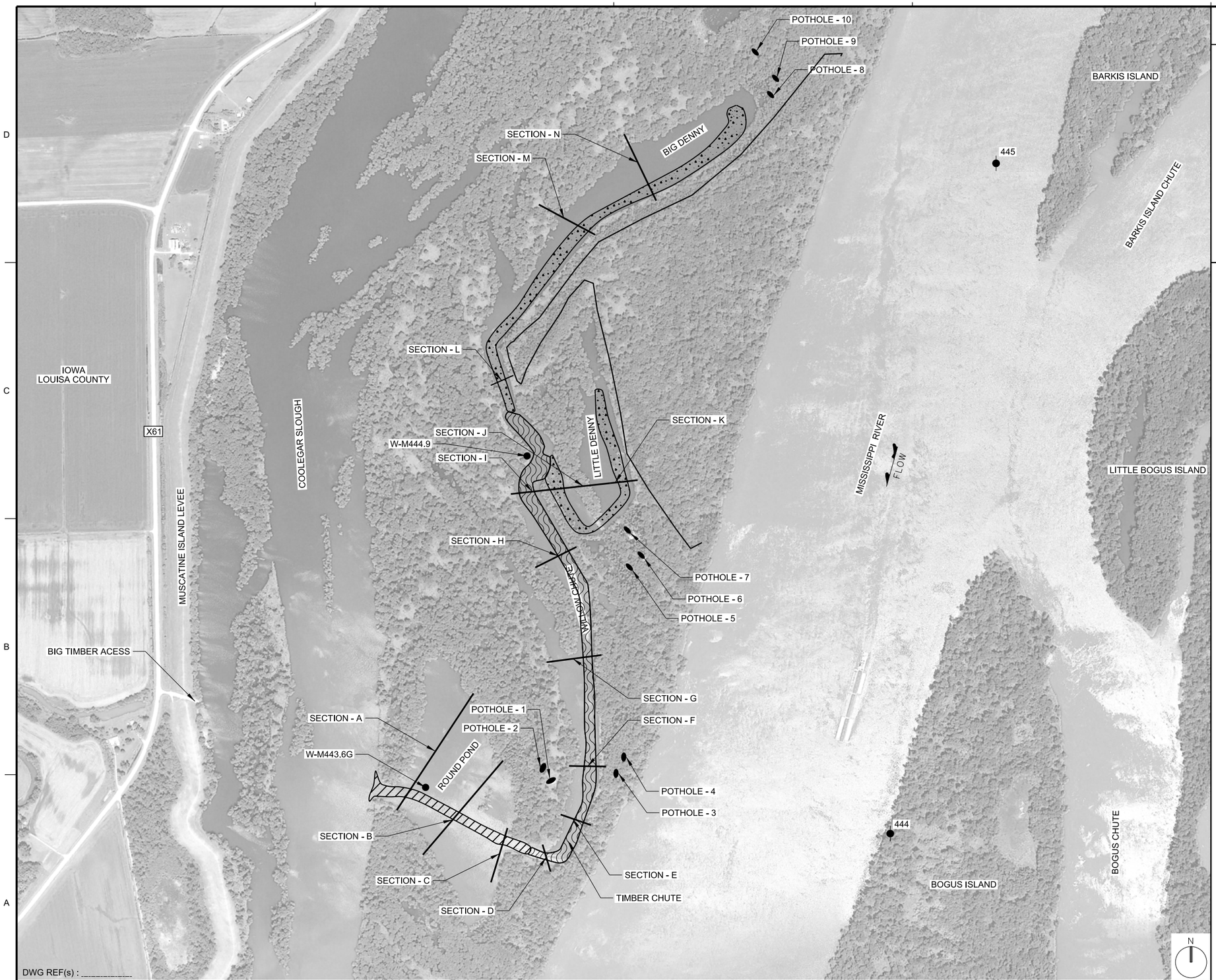
MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: SJG
DWN BY: JMF
CKD BY:
SUBMITTED BY: HLA
DATE:
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE: PER
PLOT SCALE:
PLOT DATE:
FILE NAME: PERC-312xx4.dgn
UNITS: ANSI D

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
SEDIMENTATION TRANSECT
POTHOLE 10

Sheet ID
C-312



A1 MONITORING PLAN

SCALE : 1"=400'-0" 0 400' 800'

SHEET NOTES

1. MAST TREES PLANTED ON CONTAINMENT DIKE.
2. DATE OF AERIAL PHOTOGRAPHY 2010

LEGEND

- W - WATER QUALITY
- S - SEDIMENTATION

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

DESIGNED BY: SJG	DATE:	SOLICITATION NO.:	
DWN BY: JMF	CKD BY:	CONTRACT NO.:	
SUBMITTED BY: HLA	PLOT DATE:	PROJECT CODE: PER	
PLOT SCALE: 1:1	FILE NAME: PERO-101xx.dgn		
SIZE: ANSI D			

MISSISSIPPI RIVER
RIVER MILES 443.0 - 445.0
LOUISA COUNTY, IA
BIG TIMBER PER HREP
PERFORMANCE EVALUATION REPORT
MONITORING PLAN

Sheet ID
O-101